# IRON & STEEL OF CANADA

A Monthly Magazine devoted to the Science and Practice of the Iron, Steel, Foundry, Machine and Metal-working Industries, with an up-to-date review of conditions in these and allied industries and trades

ALFRED STANSFIELD, D.Sc., Editor-in-Chief.
W. G. DAUNCEY, M.E., Associate Editor.

The editors cordially invite readers to submit articles of practical interest, which, on publication, will be paid for.
Subscriptions to any address in Canada, the United States and the British Empire, $2.00 yearly. Other countries Postage Extra. Single copies, 25 cents.
Published on the first of each month by
THE INDUSTRIAL AND EDUCATIONAL PRESS, LIMITED.
J. J. Harpell, President and Managing Director.

A. S. Christie, Eastern Manager.
H. W. Thompson, Western Manager.

Montreal Office:
35-45 St. Alexander St.
Telephone, Main 2662.

Toronto Office—
C. P. R. Building, cor. King and Yonge Sts.
Telephone, Adelaide 917.

Changes for advertisements should be in the Publishers' hands ten days before date of issue.

Vol. I. MONTREAL, FEBRUARY, 1918 No. 1




## FOREWORD.

The present century is surely an age of steel. During the thirteen and a half years of industrial expansion which proceeded the outbreak of the war no other commodity played so conspicuous a part as did steel. In the last three and a half years it has measured the offensive and defensive powers of nations, and from all appearances it will continue to play an equally important role for years after peace is declared. From all appearances the engines of peace no less than the engines of war must continue to be moulded from this metal, and the progress of any country will be proportionate to the use she is able to make of it.

Canada possesses, or can easily acquire the necessary raw material of iron ore and fuel. She has the electrical energy and the latent ability in her human forces. She lacks only a national awakening that will inspire in her people a due appreciation of the importance of her Iron and Steel industry, and provide her laboratories, furnaces, forges, rolling mills, foundries and machine shops with well trained metallurgists, chemists and mechanics.

### The Value of Efficient Workmanship.

"Capital, enterprise and energy can accomplish a great deal in promoting the welfare of any country, providing there is a foundation of efficient workmanship to build upon, but without that foundation our best efforts are doomed to failure.

"Canadian workmen as a class are possessed of great adaptability and a high order of natural intelligence, and quickly become expert machine operators, but the Canadian artisan, outside of the engineering class, usually labors under the disadvantage of not having served an apprenticeship and of having no opportunity to become familiar with the principles upon which his

**Don't forget to fill out and return the Pink Slip — See page 32.**

work is based. In a young country like Canada, whose industries are in the making, there is a constant demand for men who know how things should be done, who understand the reasons why they should be done in a particular way, who can instruct others, and who, when things go wrong, can put them right. In brief, trained men who can be entrusted with responsibility. Neither our present factory system nor our educational system makes provision for the training of such men, and in consequence our industries and our workmen both fail to make the progress they should or to reap the rewards to which their industry entitles them.

"Other countries are far in advance of us in the practical efforts they have made to increase the efficiency of their working force. The industrial pre-eminence they have secured should be an object lesson to inspire us and should determine us to do likewise."

These statements are not the deductions of a theorists but the dictum of an experienced practical man—one who has had to grapple with the handicaps of which he speaks throughout a life's work in the Canadian iron and steel industry, and in positions from the most elementary to that of president of the Nova Scotia Steel & Coal Company, which position Col. Thomas Cantley occupied at the time he gave expression to the above quotation in the course of his presidential address at the last annual meeting of the Canadian Manufacturers' Association. Quotations from many other authorities could be cited to show that the need is a real one and that the future industrial development depends more upon its solution than upon any other consideration.

### The Value of Technical Organizations and Technical Literature.

What then is the solution? If we search for it among the experiences of older countries that have attained industrial pre-eminence, there is much to support the conviction that efficient organization of industrial skill and technical literature has played a most important role. The Iron and Steel and other metallurgical institutes and associations of the United States, Great Britain and other European countries, together with many excellent trade and technical periodicals, have done much to attract brain power, awaken latent ability, encourage the establishment of facilities for technical education, and inculcate the most advanced methods in the iron and steel industry of these countries. There are only two ways of acquiring knowledge, namely, by personal instruction and by literature; and technical organization and technical literature are the best means towards this end. The establishment of technical schools is of little value without some local and national awakening force that arouses the interest of those to be benefited thereby and sets the goal for both students and teachers.

### The Organizations and Periodicals of Other Countries Cannot Supply the Need in Canada.

At first thought it may occur that the existing organizations and periodicals of other countries are sufficient for Canada. But if the Canadian boys have to look for their source of inspiration and instruction to the industrial centres of other countries, the best of them will sooner or later be attracted there; and even

Don't forget to fill out and return the Pink Slip — See page 32.

though they remain in Canada, they cannot help but feel that the professional side of their business is only a reflection of that of other countries, and the prestige of the Canadian industry and the pride they should have in it is to that extent lessened. This does not argue against Canadians seeking membership in the technical societies of other countries. On the contrary, there is much to be gained by this practice and the most progressive operators invariably follow it, just as the most progressive are habitual readers of the leading technical and trade periodicals bearing upon the science, practice and affairs of their industry, irrespective of the country of publication. But it is most important that Canada should possess similar institutions and publications of her own, —institutions and publications calculated to make known the fact that at the steel centres of this country may be seen as up-to-date and efficient methods and equipment for producing this commodity as exist anywhere in the world, and that the experts in charge are equally skilled. Also that Canadian industry engaged in the working-up of steel and other metals are turning out a product that is equal, and in many cases, superior to that of their foreign competitors, notwithstanding that many of the latter may be working on a larger scale.

## What Has Already Been Accomplished in Canada.

Heretofore, the metal industries of Canada have not been entirely without the benefit of such institutions. The Canadian Mining Institute, one of the oldest technical organizations on this continent, and one to whose influence must be credited much of the mining and metallurgical development in Canada, has always given special attention to iron and steel, and many of the most valuable papers and discussions appearing in its transactions and bulletins have to do with these subjects. It numbers among its members many of the leading and progressive men in the iron and steel and foundry industries of Canada, as well as her chief metallurgists, foundry specialists and teachers and professors of metallurgical subjects.

Realizing the benefits that have come from the establishment of branches in mining centres, the Institute has encouraged the formation of similar organizations in towns and cities possessing steel works and iron foundries. The best results along this line have been achieved in Montreal, where a local metallurgical society has been formed, with regular monthly meetings of special interest to steel workers and foundrymen.

The Institute is anxious to encourage the extension of this movement. Whether these local organizations are branches of the parent Institute or adopt other titles is a matter for the interested parties to deicde. The object of the Institute is to encourage the beginning of this important work. Once started it will work out its own career in accordance with existing requirements. At the next annual meeting of the Institute, which wlil be held in Montreal on the 6th, 7th and 8th of March, this whole matter will come up for discussion and decision, and it is the wish of the Council that as many as possible of those interested in the movement should make a special effort to be present. Whether this work should continue under the aegis of the Institute or as a separate organization with or without affiliation with the Institute is a matter for the iron and steel men to say.

**Don't forget to fill out and return the Pink Slip — See page 32.**

### The New Publication.

At the December meeting of the Council of the Institute, held at Toronto, the question of the publication, under the Institute's auspices, was considered. A Committee with authority to take action on certain defined lines, was appointed. After due deliberation, the Committee decided that the Institute might quite properly give its co-operation in the carrying out of the project to publish an independent Journal, and it was thereupon decided to proceed with the publication of "Iron and Steel of Canada," of which the present is the first issue.

### Its Policy.

The character and value of any periodical depends upon its editor. To him is entrusted its editorial policy. If the editor enjoys the confidence of the constituency his publication serves, he will be entrusted with information which, although it may not be always for publication, is necessary to the editorial course the publication should pursue. But while this course should thus be set by the industry in the case of a publication of the character of the "Iron and Steel of Canada" the editor should be strong enough to keep in the lead. He forms but a part of the council who determine the course, but should become the leader once it is set. Or in short, he should keep in sufficiently close touch with the industry to anticipate its requirements and to be able to marshal its forces for their achievement. While the editor produces only a part of the manuscript required he should be able to supplement what he does write with articles contributed by the best authorities. By encouraging correspondence and discussion both within and outside of the columns of his paper, he discovers the bright and promising minds and cultivates in them habits of study, investigation and writing, which are the fountains of progress.

Only a few of the larger companies in the constituency his publication serves can afford to engage experts capable of solving the difficulties encountered, and the technically trained editor can do much to supply this advice and thereby assist and encourage the smaller members to keep abreast of the times, not only as regards the best methods employed in Canadian industry, but as regards the best that is to be had in the industry elsewhere. This is most necessary, because if the Canadian iron and steel industry is to succeed, it must keep abreast of other countries and particularly those with which she has to compete in the markets of the world.

### Its Editors.

Ordinarily it takes years for a publication to reach a position where it is editorially capable of rendering a service as above outlined, and seldom does a new periodical make its first appearance with the promise this issue of the Iron & Steel of Canada is able to present with Dr. Alfred Stansfield as editor-in-chief and Mr. W. G. Dauncey as his associate. This is not due to the salaries paid nor to any exceptional persuasive powers of the publishers. It is due to the fact that the work to be done by this publication is simply an extension of what Dr. Stansfield has been advocating for years. As Chairman of the Metallurgical Section of the Canadian Mining Institute he is largely responsible for the attention which this work has been receiving from that organization, and he has had much to do with the inauguration and promotion of the Montreal Metallurgical Society, of which he is also president. His work as Professor of Metallurgy at McGill

University is characterized by a successful effort to bridge the gap which ordinarily exists between academic instruction and practical experience. He has accomplished this by keeping in close touch with the industry. Dr. Stansfield has also done much in the field of research, particularly as regards electrical smelting. His books on this subject are standards. He has a wide acquaintance with the industry, not only in Canada but in the United States, Great Britain and other European countries.

In proposing Dr. Stansfield for membership in the American Iron & Steel Institute, Mr. Bradley Stoughton, of the American Institute of Mining Engineers, referred to him as the one who "was largely responsible for the original suggestion whereby the equilibrium diagram of the iron and steel alloys was recognized as one of the solution diagrams which were receiving so much attention from the chemists. This principle is now the basis of the modern science of the metallography of iron and steel."

The Associate Editor, Mr. W. G. Dauncey, received his training in England. Three years ago he came to Philadelphia to solve some of the metallurgical difficulties encountered by Messrs. Stanley G. Flagg and Co., foundrymen of that city, and from there he came to Montreal as expert adviser to the Canadian Steel Foundry Co., Limited, which position he has held for two years. He is favorably impressed with the possibilities of the iron and steel industry in Canada, and has decided to remain in Montreal as a special adviser on the metallurgy of iron and steel and foundry work.

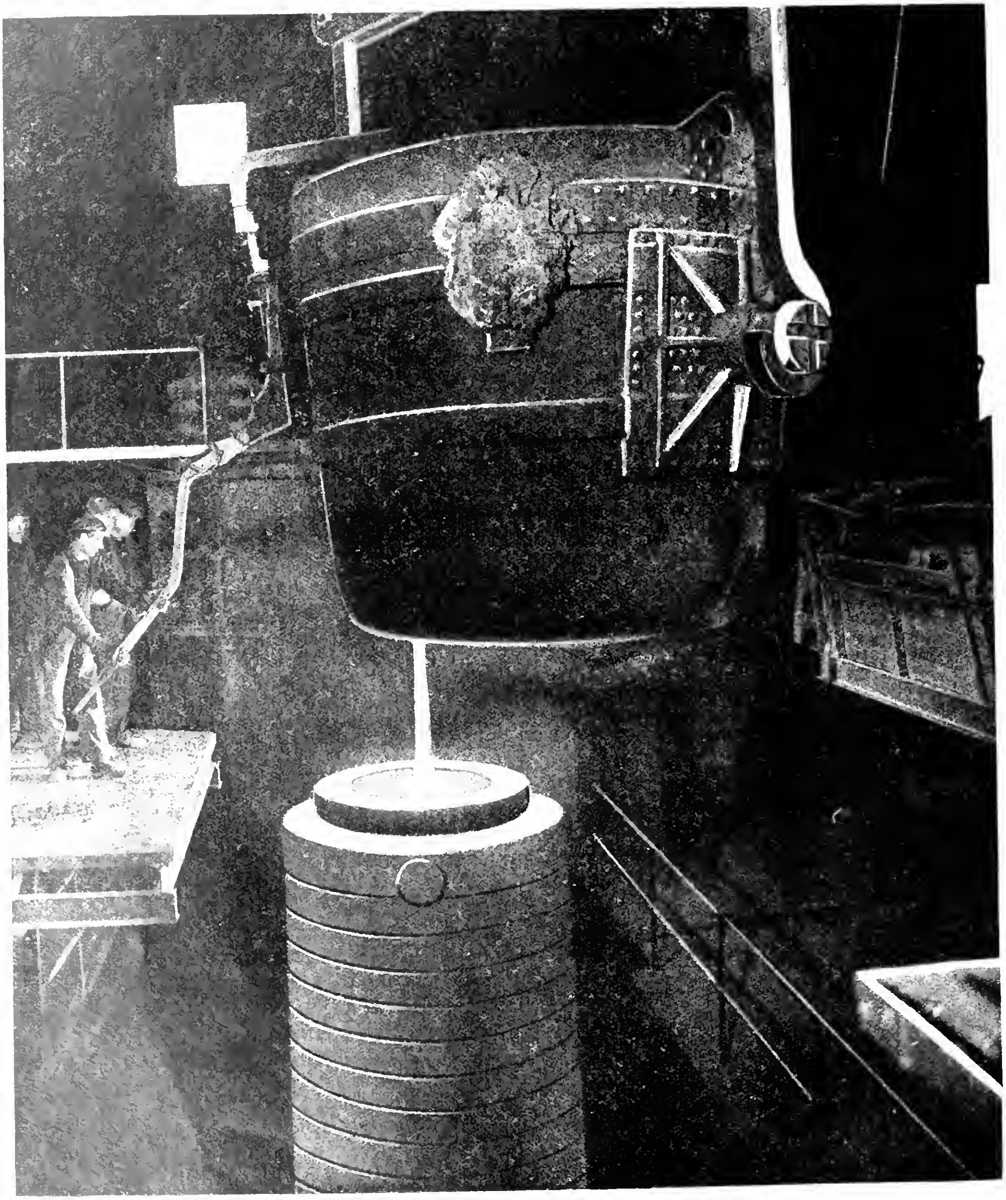
**An Appeal for the Co-operation of the Industry.**

But with the best of well qualified and earnest editors, the progress in the work we are undertaking will still be proportioned to the co-operation and support of the industry. This co-operation will be of greater value at the beginning than in later years when the work has justified itself. We therefore appeal to everyone receiving a copy of this first issue to sign and return at least one of the accompanying subscription forms. Many of the workers in Canadian blast furnace plants and foundries cannot be expected to appreciate the value of this educational effort until it has been brought to their attention and very often a sympathetic recommendation of a superior is all that is necessary. It is our intention to be pretty liberal, particularly for the first few issues, in the distribution of sample copies, and for this purpose we will be glad to have the names and addresses of anyone who should be interested in this work. But, of course, subscriptions are better. The cost of mailing a copy to a subscriber is less than one-twentieth of that of a sample copy, for the reason that the publisher receives the postal privileges only on copies going to subscribers.

We are also including in this issue a form of application for membership in the Metallurgical Section of the Canadian Mining Institute, and we would repeat the appeal made elsewhere for a large attendance of iron and steel and foundry men at the annual meeting of the Canadian Mining Institute next month. Wednesday, the 7th of March, is the day set for the special meeting of the metallurgical section, when the organization of the iron and steel and foundry interests will be taken up.

J. J. HARPELL,
President of the publishing company
**The Industrial & Educational Press, Ltd.**

**Don't forget to fill out and return the Pink Slip — See page 32.**



POURING A 30-TON INGOT OF STEEL
in the Works of
THE NOVA SCOTIA STEEL AND COAL CO., LTD.

Don't forget to fill out and return the Pink Slip — See page 32.

# EDITORIAL

## CANADA AMONG THE NATIONS OF THE WORLD.

In 1897 a system of bounties on the production of pig iron and steel ingots and several standard steel products was established by the Dominion Government and since that date the growth of the iron and steel industry in Canada has been one of the country's outstanding features.

In the year 1900 the production of pig iron in Canada was only 96,575 tons; in 1916, the annual production had grown to 1,169,257 tons.

In 1900 the annual production of steel ingots and castings in Canada was only 26,406 tons, but by the end of 1916, the annual production had grown to 1,-428,249 tons.

According to statistics compiled by the British Board of Trade and published in a parliamentary return (p. 102, price 7d.) in 1913, the per capita production of pig iron in the leading iron producing countries of the world for the year 1911 were as follows:

| | Cwt. |
|---|---|
| Belgium | 5.03 |
| United States | 5.01 |
| Germany (including Luxemburg) | 4.07 |
| United Kingdom | 4.02 |
| Canada | 2.03 |
| France | 2.03 |
| Sweden | 2.02 |
| Austria-Hungary | .80 |
| Russia (including Finland) | .40 |
| Spain (1910) | .40 |

Japan is not a large producer of iron. She is not rich in coal and even less so in iron ore. Her first modern shipyards used European iron, but lately a few blast furnaces have been established. The iron for these comes largely from the mines in Central China.

After the first sudden manoeuvre of the blighting arms of the Hun, the world awoke to the fact that the enemy of civilization had spread his tentacles around the blast furnaces, foundries and machine shops of Belgium, France and Russia, and was rapidly absorbing the output of the iron and steel industries of Sweden and Spain.

As soon as the defending forces of the Allies had recovered from the first shock and began to look around for a suitable weapon, there gradually arose the cry, which became ever louder and more insistent for "Shells, Shells and More Shells." and the only countries that were left to answer the call were Great Britain, Canada, Japan and the United States.

From that time the voices that had been raised in different parts of Canada against the system of bounties, by which the steel industry of this country was built up, died away. They realized that those who had advocated, framed and maintained these bounties had done well and wisely—in fact had built better than they themselves realized. The men who had the foresight to lay the foundation for the iron and steel industry of this country deserve and will undoubtedly have a prominent place in the industrial history of Canada and will be counted among the statesmen of their country.

What the iron and steel industry of Canada has meant to the defence of civilization is best gauged by the fact that up to the present it has contributed over one billion dollars' worth of shells. What this has meant to the national economy of the country can be best appreciated by the reminder that the purchase of these supplies outside of the country would have left an adverse international balance of the abovementioned sum. But there is a third consideration that should not be overlooked, namely, that the existence of this industry and the impetus it has received during the last three years leaves the country well prepared for the future.

The request coming from the Allies now is for "Ships, Ships and More Ships."

What a pity that Canada is not better prepared to answer this call. She has all the resources except skilled forces necessary for a large and important shipbuilding industry. She also possess many of the most important natural advantages for such an industry. At one time shipbuilding was a characteristic feature of Canada's industrial life. But lack of foresight on the part of those to whom her destiny was entrusted failed to support and assist the industry over that period of transition from wooden to iron, and enventually steel ships, and it languished. But the spark of life is still there; the resources of raw material are even greater

than before ,and the conditions, if anything, are more life giving and life sustaining than they were.

There is lacking only the political, industrial and financial leadership necessary to a public awakening of this country's needs and opportunities to fan the industry of Canada shipbuilding to a full glow of vigorous and healthy life.

The March issue of this journal will be devoted largely to a consideration of this question and it is intended to make it a topic for discussion at the meeting of the Iron and Steel section of the Canada Mining Institute on March 7th. Thus with the literature that is to be had on the subject and a careful consideration of ways and means the interest which every Canadian should take in this question will be more clear.

## EDUCATION IN THE FOUNDRY.

Metallurgy is one of the most ancient of the arts; the early Babylonians and Egyptians, more than 5000 years ago, extracted the metals gold, iron, copper and lead from their ores, and used them for tools, weapons and ornaments. Knowledge increased very slowly, however, and while steel, which is so essential for making tools, was known in very early times, cast iron, the basis of our modern iron and steel industry, was not produced until about 1450 A.D. Crucible steel was invented in 1740. Bessemer steel in 1856, and the open-hearth process about 1863. During the past 200 years the practice of metallurgy has grown and improved with increasing swiftness; not merely have the operations been on a larger scale and the works more numerous, but the processes themselves have been more complex, more nicely adjusted to the end in view, and more economical and efficient in their operation.

The modern rise of metallurgy has been connected with the growth of modern science, which is only about 100 years old, but the workers in so old an art as metallurgy were naturally conservative, and have been slow to take advantage of scientific methods or of scientific explanations of metallurgical processes. This state of things has now passed, and the management of any up-to-date steel works, foundry or machine shop, is eager to keep up with the latest advances in metallurgical science. It is very difficult, however, for busy men to read all the papers and discussions of these subjects to be found in the transactions of technical societies, such as the Iron and Steel Institutes and the various Mining, Engineering, Chemical and Electrical Societies. It is recognized now that to obtain the best results in metallurgical operations it is essential that the foremen and workers should themselves have some scientific knowledge of the processes they are engaged in, but the papers referred to are written in technical language and require a preliminary education of which the foremen and workers can rarely boast. These difficulties are very real, and hard to overcome, but we shall try to present from time to time the most recent developments of metallurgical knowledge in a simple and intelligible form. We shall be glad to receive any criticism in regard either to the matter or the manner of these articles, and to receive requests for information along any lines connected with iron or steel metallurgy.

## MONTREAL METALLURGICAL ASSOCIATION.

This Association was formed early in the war for the use of the metal workers of this city. Montreal contains a large and increasing number of metallurgical works where steel, cast iron, brass, copper and other metals and alloys are melted, cast and worked, and this Association has proved useful for discussing the difficulties which are bound to attend the inception and growth of metallurgical industries, and for disseminating scientific knowledge having a bearing on the production, heat treatment and working of these metals.

It is intended in these pages to print reports of such papers and discussions of the Association as may be of interest to iron and steel workers, and it is hoped that this journal may receive similar reports from metallurgical societies throughout Canada, and may serve as a bond of union between them as well as an aid in starting such associations in suitable centres.

## ELECTRIC FURNACES IN THE IRON AND STEEL INDUSTRY.

The first electric furnace of any practical importance was constructed by Sir Wm. Siemens in 1878, and in 1882 he melted in an electric furnace some 20 pounds of steel and 2 pounds of platinum. Electrical power has always been a costly source of heat and until a few years ago it was not supposed that electrical heat could be used commercially for melting steel or reducing iron from its ore. In 1898 Captain Stassano, in Italy, patented an electric furnace for melting iron ores, and about 1900 the first important steel-making furnaces were invented by Heroult and Kjellin. Since that time the advance has been rapid, and electric furnaces for melting or refining steel have become quite common in all parts of the world. In this country the electric steel-furnace has been introduced largely since the beginning of the war as a convenient means of producing steel for shell making. In the United States electric steel-furnaces are said to have a productive capacity of 1,000,000 tons per annum. These furnaces are generally used for melting steel scrap for the production of steel ingots or castings, sometimes merely to refine molten steel that has been made in the Bessemer or open-hearth furnace, and scarcely at all for the production of new steel such as is made in the open-hearth furnace from pig iron, iron ore and steel scrap.

In Sweden, and to some extent in California, electric

furnaces have been used to smelt iron ore for the production of pig iron; this subject is worth our careful consideration in a country which resembles Sweden in many particulars. The production of iron and steel is limited in most parts of Canada by the absence of coking coals and hematite ores suitable for smelting in the blast furnace. We have, however, many water falls from which electrical power can be generated, and with the assistance of wood charcoal or even peat charcoal it may be practicable to smelt our own magnetite ores for the production of a high grade white pig iron which at present can scarcely be obtained in this country.

We intend, in these pages, to discuss in some detail the possibilities that offer themselves in this direction and also to give descriptions of the various electric steel-making furnaces and of the principles that underlie their construction and operation. We shall be glad to receive questions or criticisms in this connection, and shall endeavor to answer such with reasonable promptness.

## IRON AND STEEL INDUSTRY ON THE PACIFIC COAST.

Public men in British Columbia are at the present time drawing attention to the iron ore resources of that province and making an effort to awaken capitalists to the advantages to be derived from the establishment of an iron and steel industry on the Pacific Coast. As far as we know at present, British Columbia does possess an adequate tonnage of magnetic iron ore to meet the requirements of a small steel industry, but whether there is sufficient tonnage to warrant the establishment of an iron and steel industry on a large scale is a question that only future developments can answer. There is no doubt that if an iron industry were established, prospecting for iron ores would be more popular than it is at the present time in British Columbia, and there is a possibility that valuable discoveries would be made.

## THE IRON AND STEEL INDUSTRIES OF CANADA.

It is appropriate that in the first issue of the "Iron and Steel of Canada," we are able to present a monumental paper by Mr. Corbett F. Whitton, dealing with the present position and probable future developments of the iron and steel industries in Canada. Mr. Whitton describes the principal plants, the sources and cost of assembling the raw materials, the nature and amount of the products, and the markets where they are disposed of. He compares the amount and variety of the products from Canadian plants with what is imported from abroad. He compares the cost of production of various iron and steel products at Canadian and American works, and also the cost of transporting their products to Canadian markets. He concludes by considering what possibilities there are of increasing the variety and tonnage of steel products manufactured in Canada; and by what measure the Canadian steel industries can be fostered and protected.

Mr. Whitton's paper was presented at the last annual meeting of the Canadian Mining Institute and his conclusions, and those of the speakers who discussed his paper may need some modification in view of the altered conditions at the present time. Mr. Whitton has, however, revised his paper since it was first presented and the data contained in it will form a valuable basis for further considerations of the iron and steel situation.

## SHORTAGE OF STEEL SCRAP.

The shortage of suitable scrap for open-hearth steel production is very rapidly assuming acute conditions in Canada; many plants have had to curtail production and others have closed down altogether. Several causes have operated to bring about this condition amongst which may be enumerated that the railway companies are reforming and re-using iron and steel work from wrecked cars, all of which formerly reached the scrap pile; again cars are not being replaced in the same proportion. Another factor is the lower rejection percentage with shell steel, it used to be common for this figure to run around 15 per cent. and this, plus the 20 per cent. discard, was returned to the open-hearths. Now with many works running on a very low foundry loss, due to rejections, some even under 1 per cent., this source of supply has practically ceased to exist, and at one plant this means a shortage of scrap equal to 75 tons per day. From the financial point this reduced rejection percentage is eminently satisfactory, but it is none the less one factor in the scrap shortage problem. It is not easy to suggest a solution for this situation, but ones first idea would be to more closely follow European practice and increase the percentage of pig-iron in a charge, this, however, is impracticable for available supplies of suitable pig are very limited, due primarily to the fuel situation, or shortage of coke. With the object of relieving the position by every possible means all works operating mills in conjunction with blast furnaces should be compelled to refrain from sending scrap from the former back to the latter. Again every ounce of turnings produced when machining shells, should be kept as clean and free from oxidation as possible prior to being returned to the open-hearth furnaces; granted these are not ideal stock owing to heavy melting losses and the danger of introducing oxidized metal into a charge, that turnings can be used without serious furnace trouble, or detriment to the steel, has been very fully demonstrated, and some plants are using up to 25 per cent. in their practice. Wherever possible, it is wiser to use turnings for basic steel for which they can be charged directly on to the hearth and more easily covered and protected from oxidation. Under all the circumstances it seems that an increased supply of pig is the most hopeful source of relief and this can only be made available by an improved fuel condition, which in turn would enable the blast-furnaces to force production.

**Don't forget to fill out and return the Pink Slip — See page 32.**

# Production and Use of Ferromanganese

The conditions brought about by the war have interfered very seriously with the supply of ferromanganese which is needed in the manufacture of steel. The importance of this material can be seen from the statement that each long ton of steel requires 17 pounds of manganese in its production. Manganese ores for the production of ferromanganese have been obtained in the past from the Caucausus Mountains of Southern Russia, from India and from Brazil. Owing to the closing of the Dardanelles the Russian deposits have been cut off, and the long distance to India coupled with the shortage of ships made the Indian fields almost unavailable. The result is a very serious shortage in ferromanganese.

Under these conditions it is worth while considering how far it may be possible to produce ferromanganese in Canada, and if possible from Canadian ores. Unfortunately the ores of this metal are not found very freely in this country, and are in general of low grade. The situation is somewhat similar in the United States, and papers which have recently appeared in American publications have an important bearing on the situation in this country. Among these may be mentioned: "Utilization of low grade manganese deposits—"a metallurgical problem," by J. E. Johnson, Jnr., Engineering and Mining Journal, December 15, 1917, p. 1027. From this paper several important ideas may be obtained. In making steel by the Bessemer process, the low grade product spiegeleisen, containing about 20 per cent. of manganese, 5 per cent. carbon and the rest iron, was usually employed, but for the production of low carbon steel in the open-hearth furnace it has usually been necessary to employ ferromanganese containing 80 per cent. of manganese, about 6 per cent. carbon and the rest iron. Ferromanganese is used instead of spiegeleisen when it is desired to obtain a low carbon steel because in that case the amount of spiegeleisen necessary to give the desired amount of manganese would also impart too large a proportion of carbon. Mr. Johnson points out that a large amount of steel from the open-hearth furnace is required to contain so much carbon that spiegeleisen could be used with entire satisfaction, and he advises that this should be done so as to leave the more expensive material—ferromanganese for those purposes for which it alone can be used. In the production of ferromanganese it is necessary that the ore employed should have a high percentage of manganese in proportion to the amount of iron present, and this makes it impossible to use many low grade ores for the purpose. These low grade ores can, however, be used for the production of spiegeleisen, and hence it is desirable in the present situation to use spiegeleisen as far as possible in the manufacture of steel instead of ferromanganese. It may further be possible to use lower grades of the manganese alloy containing for example 70, 60, 50, 40 and 30 per cent. of manganese, which can be more easily produced than the 80 per cent. alloy, and are especialy suitable for certain purposes.

Spiegeleisen and even ferromanganese has been made largely in blast-furnaces, but for several years the practice in Europe has been tending towards the use of the electric furnace. This appliance, while somewhat more costly to operate on account of the price of electric power, utilizes the ore more perfectly, and has the further advantage of producing a ferromanganese which is lower in carbon than the product of the blast-furnace. This is particularly the case if a silico-spiegel is produced—that is a manganiferous pig iron which is also rich in silicon. The objection to the use of spiegeleisen being that it imparts too much carbon to the steel. It will be seen that a lower carbon product, even if low in manganese, can be used more widely than the old variety of spiegeleisen; thus allowing of the use of low grade manganese ores for the production of ferromanganese and spiegel.

Another paper of interest in this connection is the "Utilization of Manganese Ores in Sweden," by J. Harden, Metallurgical and Chemical Engineering, December 15th, 1917, p. 701. This paper takes up the possibility of the production of ferromanganese and spiegeleisen in Sweden so as to avoid the need of importation. The paper enumerates the ores of manganese; speaks of the production of spiegel and ferromanganese in the blast-furnace in England and America; but states that the loss of manganese is very high owing to the volatility of that metal and to the loss in the slag. On account of these facts the electric smelting method has been widely adopted and often supersedes the old method; this is particularly true in Sweden and other countries where the supply of ore is limited and charcoal is becoming more expensive and where electric power can be had comparatively cheaply — ten dolars or less per horse power year. The smelting of manganese ores is carried out in a single-phase or 3-phase furnace having a conducting hearth. The furnace is charged with a mixture of ore, coal and flux at regular intervals; metallic iron being added if necessary to give the right proportion in the product. The consumption of power depends on the size of the furnace, the proper handling of the charge and operations, and also on the desired percentage of carbon and silicon; but a 3-phase furnace with a capacity of 3,000 kilowatts should not consume more than 8000 to 8500 kilowatt-hours per ton of ferromanganese. The furnace should be worked so that the electrodes are covered and no open arc is formed, as this would entail losses of manganese and higher consumption of electrical power; over-heating of the metal must also be avoided. A typical analysis of electric furnace ferromanganese would be: manganese 81 per cent., iron 12 per cent., carbon 6 per cent., silicon 0.6 per cent., phosphorus 0.08 per cent., and sulphur 0.03 per cent. To get a lower percentage of carbon it is usually desirable to carry out the process in two operations—smelting the ore for a high carbon product in the first furnace and remelting this with the addition of manganese ores in the second furnace. The cost of such material will consequently be somewhat higher. Silico-managanese is obtained by adding quartz to the charge; the product will contain about 70 per cent. manganese, 18-20 per cent. silicon and 6 per cent. carbon.

In regard to the use of ferromanganese, it is pointed out that in the Bessemer converter spiegeleisen is melted and poured into the converter where it has every chance of becoming thoroughly mixed. Ferromanganese on the other hand in basic open-hearth steel practice is added in a crushed form in the ladle, and

Don't forget to fill out and return the Pink Slip — See page 32.

until recently it was added in lumps. There was then a serious danger that these lumps might not completely dissolve and mix before the steel was solidified in the ingot. The result of this imperfect mixture was one cause of the so-called "ghost-lines" which in that case are hard portions of the steel containing a high proportion of manganese. These "ghost-lines" are very detrimental to the steel especially when it must be machined. The best way to avoid this result is to pour the ferro in a liquid state into the steel in the ladle. For this purpose the electric furnace has been found to be the most suitable melter; a furnace of the Roechling induction type being suitable. The writer has seen one of these furnaces in operation for this purpose in a steel works in Germany.

In connection with the need of ferromanganese for steel making on this Continent a complete bibliography of the manufacture of ferromanganese has been prepared by Mr. E. C. Buck, and will be found in Metallurgical and Chemical Engineering, December 1st, 1917, p. 638. In view of the need of ferromanganese in this country it is to be hoped that those who have deposits of manganese ores will bring them to the notice of electric smelting firms who may be in a position to work them up for ferromanganese or spiegeleisen, and that the steel makers will devote some consideration to the possibility of economizing ferromanganese by the use of the lower manganese products.

# Metals and Metallurgical Research*

PROF. S. F. KIRKPATRICK.

The metals have played an important part in the development of civilization from the earliest historic times down to the present. They have been a factor in determining the fortunes of war. The bronze armed warrior drove out the man of the stone axe and the iron equipped soldier in his turn subdued the bronze armed races. History tends to show that the claim "the strength of a nation can be judged by the success with which it practices the metallurgical arts" has a true foundation.

This is not, however, generally appreciated, and the Japanese in his worship of his sword and the swordmaker is an exception rather than the rule. The iron worker has held an honorable position as typifying honest toil rather than as holding a position in the fore-front of the civilization of his country.

To-day as never before the rulers of the nations recognize the part that the metals play in determining the fate of nations.

Great Britain was the greatest coal, iron, and general metal manufacturer of the 19th century and as such was secure in her premier position among the nations. Germany, however, early recognized the need of iron and steel for the furtherance of her scheme of conquest, and as early as 1870 exacted from France as penalty of defeat what was then supposed to be practically all the iron fields of the Minette district of Alsace-Lorraine, the most important iron ore reserve in Europe.

With this resource and her own coal fields around Essen, Germany then proceeded to foster her steel industry, increasing her steel production in the quarter of a century immediately preceding the war almost twelve times from 1,600,000 metric tons in 1888 to 19,300,000 metric tons in 1913. During this time Great Britain's output increased only two and one-half times from 3,000,000 metric tons in 1888 to 7,500,000 metric tons in 1913. That is, at the beginning of the quarter century preceding the war, Great Britain produced twice as much steel as Germany, while at the end of that period Germany's production was two and one-half times that of Great Britain. Fortunately the production of the United States increased almost thirteen times during this period from 2,400,000 metric tons to 31,000,000 metric tons.

It is interesting to note that preparation for hostilities was probably one of the chief causes of the activity of the German steel industry during the years immediately preceding the war. For instance, part of the energy of the iron manufacturer was directed to the building of the strategic railways on the East and West fronts that in many cases were required for no other purpose than that of the rapid mobilization of troops. The German steel industry also led in the production of war munitions, such as the manufacture of cannon. The Belgian forts were equipped with Krupp guns that could be blown to pieces by larger guns manufactured in the same works.

It might also be said that Germany's success in the manufacture of steel was an important factor in encouraging her to defy the other powres of Europe.

When war started the main strategy of Germany was to cripple France in her coal and iron resources and by the advance through Belgium into the northern part of France, Germany came into temporary possession of almost all the iron and coal of continental Europe. This would have been disastrous to French hopes if it had not been that Great Britain was ready, pressed though she was, to come to her assistance. We are only beginning to understand now how serious the situation was in the fall of 1914.

Germany was not so well situated in regard to some of the non-ferric metals, especially copper, as she was manufacturing only three per cent. of the world's copper before the war, while consuming thirty per cent. But even in this industry we can see her appreciation of the metals, as some of the copper mines were said to be operating at a loss before the war, and were being kept open only by government aid. This was then said to be a splendid example of the paternalty of the German government that wished to keep this industry on its feet so as not to have to throw so many miners and metallurgists out of employment. Now we are able to appreciate that there may have been other reasons for Germany's encouragement of this industry.

Since the war started, needless to say, all those closely in touch with military operations recognize the value of the metals, as they are required for all parts of the huge army and navy machines. Never before has the need of replacing manual labour with machinery been so keenly felt in the industries.

Even an industry such as agriculture, often rather antagonistic to the industrial life of the country, is becoming more than ever dependent upon the metals

*This article appears in the January issue of "Queen's Quarterly."

and their successful manufacture into farm employment. As an example, when Great Britain was first confronted by the intensive submarine war the authorities recognized the need of developing her neglected agriculture resources, but they had no men to throw on the land. It was to the machine manufacturer that they appealed and thousands of farm tractors were rushed over from the workshops of America to take the place of the army of men that would otherwise have been required.

The great need of metals is to-day emphasized by the recognized necessity of steel for ship building. The iron manufacturing resources of the United States, great though they are and stimulated by high prices, are being taxed to the uttermost. Government orders take first place and the civilian consumer has often to wait. The tendency is to curtail all uses of metal that are not of immediate national importance.

This growing importance of the metals is not only a war effect, for the annual production of iron and steel in the United States has regularly doubled every ten years for the last century, and the end is not yet. Only part of this increased production is due to the increase of the population of that country as the production of iron in the world has increased about fifty per cent for each decade for the last century.

This increase is followed by the other metals, copper having increased about six-fold in forty years, and the latest addition to the family of common metals, namely, aluminum, showed a tenfold increase in the first decade of its use and a tenfold increase during the second decade. It is too early to say what the increase will be during the third, but it will be a very large one.

Not only is there a steady increase in the production and consumption of metals but in the variety of alloys or mixtures of metals employed in the industries. Every part of the modern complicated machines of industries, of railroad equipment, army equipment, naval force or flying machines, is studied in order to adapt to each the metal or alloy best fitted to give the greatest service.

This entails a knowledge of metallurgy undreamed of fifty years ago. Now we use iron alloyed with various proportions of one or several of the following elements: Carbon, silicon, manganese, copper, chromium, tungsten, molybdenum, nickel, cobalt, uranium, titanium, vanadium, zirconium, aluminum.

Many of these elements are so important in conferring valuable properties on steel that it has been suggested for each in its turn that a nation cut off from its use could not wage a modern war. This claim has been made in technical and popular literature for nickel and it is only a short time ago that the Ontario people and press were much exercised over the chance that some of the nickel of Canada was finding its way to Germany. Chromium is as essential as nickel in manufacturing armour plates and projectiles.

A strong claim has been made for the vital importance of tungsten. This metal is used in the production of high speed steels and it has been claimed that if this metal could not be obtained the ability of the workshops to produce shells and other war materials would be reduced to a fraction of their present capacity due to the fact that the ordinary carbon steel cuts so slowly. Manganese is another metal almost essential to the manufacture of steel, and America is feeling a shortage of this metal at the present time.

The metallurgy of to-day is becoming a well-developed science, while only fifty years ago it could be considered an art. The properties of metals are determined by the chemist and metallurgist with the assistance of physical testing laboratories rather than, as formerly, by the artisan. It is therefore to the trained chemist and metallurgist that we look for development in the production and use of the metals. Research of an industrial and scientific nature is becoming a more important factor.

This work has a bearing on the problem of the shortage of labor. In conection with the production of the metals themselves the tendency is to develop processes of the treatment of ores that will require few men to operate them. We now have large mills crushing and concentrating ten to twenty thousand tons of ore per day, operated by a mere handful of men.

Research also tends towards the elimination of waste. Twenty years ago most of the concentrating and metallurgical plants would have thought they were doing good work if they recovered 70% of the metals in an ore, now 90 and 95% would be expected and obtained. There has also been a development in the method of treating refractory ores containing a mixture of several metals. A few years ago the smelter would have been content to treat the ore for the recovery of one or two of the metals and to let the others go to waste. The modern metallurgist is not satisfied unless he is extracting and marketing all the metals in the ores. Much has been done in this line but there is still much to do though each year as it passes sees important gains made.

The war has only intensified the need for these economies and emphasized the need for all the metals we can produce. It also shows the necessity of a country adapting itself to its own resources. This is forcing a greater development in the science and industry of metallurgy than that experienced before the war.

On account of the closing of certain trade routes and the shortage of shipping facilities, America is largely on her own resources. No longer can she depend on the sulphur from the pyrites of Spain or on the manganese from Russia and India, nor altogether on the chromium of New Caledonia or Africa, or the tungsten of India. The metallurgists of America can and are replacing these ores by intensive search into the mineral resources of the country and by developing deposits formerly considered unworkable. New metals are also being developed and new alloys manufactured.

What is Canada's part in this work? We who are sending 500,000 men to France are one of the principal metal producing nations of the world and have a responsibility in regard to this development in metallurgy and the adapting of our metal resources to war requirements.

It is only within the last fifteen or twenty years that Canada has been actively developing her mineral resources and manufacturing metals, but she already takes an important place in the production of iron and steel, copper, lead, aluminum, and is the fourth country in order of gold production. This country also produces one-eighth of the world's silver, one-quarter of all the arsenic consumed on this continent, and has the leading place in the production of asbestos, nickel, and cobalt. Only within the last two years under stress of war conditions metallurgical researches have

**Don't forget to fill out and return the Pink Slip — See page 32.**

added metallic zinc and metallic magnesium to the list of her products.

The main object at the present time is to be the intensive production of those metals of prime importance for war purposes, but almost all of the metals mentioned come under this head. Steel, formerly so largely used for structural purposes, is in greater demand for war munitions and ships, copper for brasses, lead for munitions rather than paint, aluminum for army equipment and flying machines, and silver, generally considered as a luxury, is in greater demand than ever for the manufacture of currency. Canada supplies the arsenic for the insecticide requirement of over 25,000,000 people. Nickel is primarily a war metal, and cobalt, although used before the war practically altogether in the ceramic industry, is now largely consumed as an ingredient of high speed steel and in the manufacture of the new tool metal, stellite, used largely for the turning of shells.

The mining and metal production of Canada will be an important factor in post-war conditions, as an abundance of metals will be required during the building up stage, and with the influx of labor Canada should be able to supply these from her developed and undeveloped resources.

# A Recent Improvement in Cast Iron Moulds

During the strenuous work of the last three years with its enormous demand for cast steel blanks suitable for making high explosive shells, constant efforts have been made to reduce costs and losses, and to improve the quality of the ingots produced. In the early days of this work it was customary for The Imperial Munitions Board to let contracts for so many blanks, but only to supply an approximate weight and size for each blank. To illustrate this point when eight-inch blanks were called for the dimensions given were: $17\frac{1}{4}$ inches long and $8\frac{5}{8}$ inches in diameter.

This blank had to be forged with a rounded nose, due entirely to the shape of ingot being used. Realizing that it would be quite impossible to make satisfactory forgings from such blanks The Canadian Steel Foundries asked for permission to design and try out a new type of blank. This experiment necessitated

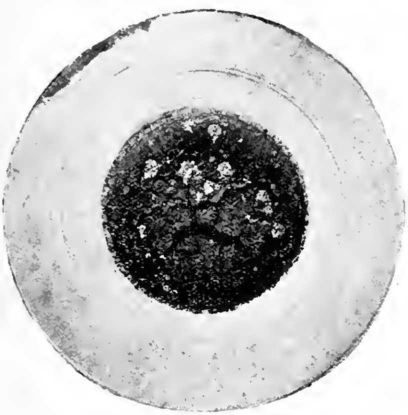


Illustration "A"—Cracks in base of solid mould.

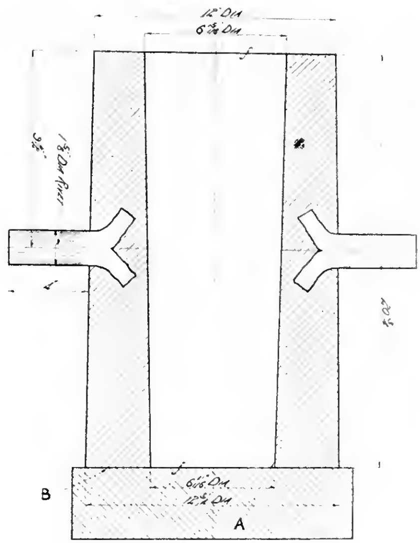



Figure "B"—Original type of mould used for 6 inch blades.

but in trying to do so physical defects developed, these were not due to inferior steel but to the mechanical effect of the work necessary for forging. The die pot used would allow the blank to enter for about two thirds of its length when its descent was arrested by the contraction of the pot, where the rounding for the nose commenced. Whilst in this position the piercing plunger, in passing down the centre, exerted a telescopic action due to the fact that the outside edge of the bottom of the blank was securely held whilst the central portion was free and being forced downwards by the plunger under a pressure of approximately 500 tons. This unfair treatment of steel at between 2150° F. and 2250° F., caused internal tears which the inspectors attributed to defective metal, but were in reality caused by stresses severe and abnormal the use of a solid bottom mould for the blank designed roughly conformed to the outline of a finished forging, and this was the introduction, as far as Canada was concerned, of a mould with a closed end. The ingot produced was in every way satisfactory, but the descent, on to a cast iron bottom of an intensely hot stream of fluid steel was found to be very severe. After a varying number of heats the bottoms developed cracks as shown on illustration "A," and these in turn were instrumental in giving rise to two troubles, first the fluid steel entered these cracks and frequently caused "stickers" or ingots that remained fast to the mould, and where this was not the case the ingot was

Don't forget to fill out and return the Pink Slip — See page 32.

so rough and irregular on the base that expensive grinding became a necessity. The solid bottom notwithstanding these conditions was so successful in giving a sound pipeless ingot that it was adopted and proved commercially satisfactory, because the extra cost of moulds was more than compensated by the marked reduction in rejected blanks; as a matter of fact, 40,000 blanks were cast as a first experiment

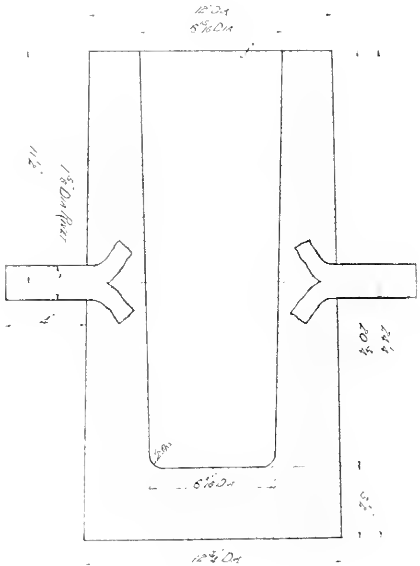


Figure "C"—First design of solid bottom mould.

for a foundry loss of 1.86 per cent. After applying this same type of mould for 9.2 inch work. The Munitions Board gave orders for 6 inch blanks to be produced and the design was again a parallel one. This size gave more trouble than any of the others and the losses due to pipe, pipe indications; or segregated areas were abnormally high. The proportions of this blank were wrong and it was difficult, if not impossible, to produce a perfectly sound ingot, in almost every case a split blank would show evidence of a very loose central structure, or secondary pipe. Again The Canadian Steel Foundries asked for permission to redesign the blank and the type finally adopted has been eminently successful, in fact, three of their plants have produced upwards of 800 heats for a foundry loss of under one per cent. The trouble with mould bottoms still continued, however, and it remained for Mr. J. I. Reid to solve the problem and materially reduce the mould cost per ton of steel produced. With solid bottom moulds one frequently sees the bottom burned and cracked so as to be quite useles whilst the inside walls are perfectly clean and uncut. It would be safe to assume that the average mould would have a tenfold life if bottoms stood up as well as walls, and Mr. Reid's idea makes this possible. Figure "B" serves to show the mould originally used when demonstration had proved that a taper-blank was the most satisfactory and yielded the soundest ingot. This mould stood upon a cast-iron, or steel stool-plate, but the trouble incidental to its use was that it was practically impossible to keep a tight joint between mould and stool-plate as at "B," on figure "B." A breaking away of the inside edge of the mould after slight service would allow metal to enter between the two faces, this immediately froze causing a horizontal fin or lock. The same thing occurred at the top between the mould and bush, with the consequent result that the extreme ends of each blank were sometimes immovably fixed whilst the centre was still in a fluid condition. Then as cooling, or freezing progressed, contraction was retarded and a circular crack would develop two or three inches below the top of the ingot. This trouble led directly to the introduction of the solid bottom mould as shown by figure "C." This design completely avoided any possibility of a bottom fin but left the burning of bottoms still to be overcome. Figure "D" shows how, by Mr. Reid's design, the full life of side walls can be utilized regardless of

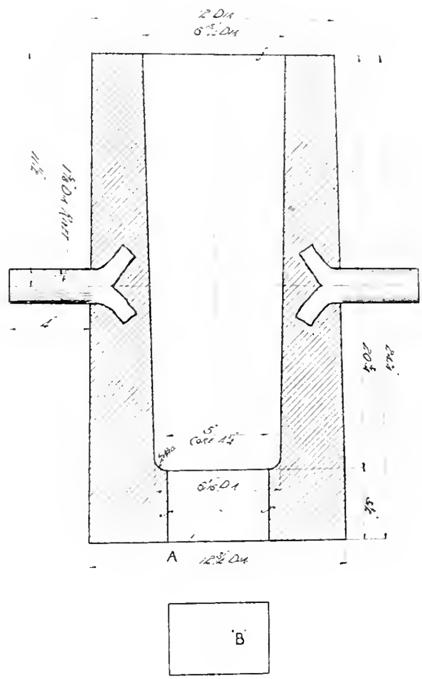



Figure "D"—Reids' design for solid bottom moulds.

the condition of the base. The original mould instead of being cast solid has a circular hole cored through the basis 5 inches in diameter; this, when the mould is mounted on a lathe for facing off, is bored out ,and a plug shown at "B" on figure "D" is driven in to form a solid base. By this means any number of bases can be used with one mould thus obtaining the advantages of a solid bottom design, and also the maximum service from side walls. The decided economy of this mould at once becomes apparent when one considers that a new one costs around $27.00, whilst a fresh base can be cast turned, and placed in position for approximately $1.50.

Don't forget to fill out and return the Pink Slip — See page 32.

# The Montreal Metallurgical Association

A meeting was held on the 19th December, 1917, and was devoted to a discussion of the subject, "What happens in the steel furnace."

The meeting was opened by Mr. S. W. Werner, who showed a number of lantern views illustrating the history of iron and steel metallurgy from the most primitive furnace up to modern times.

Mr. Davidson, of the Thomas Davidson Company, described the difficulty they encountered in imparting carbon to steel in the acid lined electric furnace (Snyder type.) Their stock consisted of low carbon steel scrap, and when this was melted they found it necessary to carburize it by the addition of some form of carbon such as graphite, hard coal, coke, or wood charcoal. In normal melting, without the addition of carburizing material, the phosphorus and sulphur contents were raised about 10% above the initial amount owing to furnace losses, etc. With the scrap at present in use this meant an increase of 0.004% or 0.005%, but occasionally, when using hard coal, or coke, the increase in sulphur might be as much as 0.04%. Wood charcoal on the other hand is unsatisfactory because so much of it is burnt in the furnace.

Dr. Stansfield pointed out that the best plan would be to use a pure variety of pig iron for re-carburizing, but that at present such iron was almost unobtainable in Canada. In the past there was a steady production of pure pig iron from charcoal blast-furnaces, but unfortunately this had stopped. He considered that there was a very good opening in this direction for the introduction of electric smelting of the titaniferous magnetites for the production of high quality pig iron, which could be used for this and similar purposes. The higher price obtainable for such a product would quite meet the difference in price between electricity and coke.

Lieutenant Patterson asked what was the difference in nature and effect between the flame of the electric arc and the gas flame in the open hearth furnace. Mr. Davidson replied that he considered them both the same, except that the electric flame was somewhat hotter and that it was free from injurious ingredients such as were sometimes present in the open hearth flame. He had not found any difference in the resulting steel which could be attributed to a difference in the flame.

Dr. Stansfield pointed out that while heat was undoubtedly produced in the electric flame and radiated from it to other parts of the furnace, yet in heating by electric arcs, heat was produced to an even greater extent in the solid or liquid materials between which the arc was struck. In the steel furnace this meant the end of the carbon electrode and the metal or slag immediately beneath the arc. The heating by electric arcs was thus more direct than in the case of the open-hearth furnace, where the heat from the flame only reached the metal by radiation and conduction.

Mr. Davidson spoke of the difference in quality between steel of the same composition obtained from the acid electric furnace and the basic open-hearth furnace. At the request of Dr. Stansfield, Mr. Davidson and Lieut. Patterson gave the following figures as representing the percentage of carbon in steel produced by different processes and having equal mechanical properties. It appeared that the steel from the acid electric furnace had the greatest strength for a definite composition, or, conversely, the smallest carbon contents for a definite strength.

**Steel Having Equal Strength.**

| | Lt. Patterson. | Mr. Davidson. |
|---|---|---|
| Basic, open-hearth . . . | 0.50% carbon | 0.54% carbon |
| Acid, open-hearth . . . | 0.47% carbon | 0.48% carbon |
| Basic, electric . . . . . | 0.44% carbon | 0.46% carbon |
| Acid, electric . . . . . | 0.42% carbon | 0.42% carbon |

Mr. Lindstrom considered that the difference in strength of acid and basic steel was caused mostly by the difference in phosphorus. He was of the opinion that phosphorus formed a different combination in an acid steel from what it did in a basic steel, and that this would explain why acid steel might contain without injury decidedly more phosporous than was allowable in basic steel, with the result, as was shown by Mr. Campbell, of increasing the strength of acid steel as compared with basic steel of equal carbon contents.

Mr. Spencer questioned whether phosphorus existed in different forms in acid and basic steels, but suggested that this might be demonstrated by means of the microscope.

At the request of Mr. Roast, Dr. Stansfield gave an elementary account of the removal of phosphorus and sulphur in the basic open hearth furnace. With regard to sulphur he said that the mechanism of its removal was not well understood, but that apparently it must form calcium sulphate in the slag as the conditions in the furnace were oxidising, which would render impossible its removal as calcium sulphide.

Mr. Lindstrom discussed this point stating that the experiment had been made of throwing into a basic steel-furnace a quantity of calcium sulphate. The effect was to increase the sulphur in the steel, which seemed to contradict the idea that sulphur was removed in the slag as calcium sulphate. He was of the opinion that the sulphur was ultimately removed by volatilization in the furnace. On the other hand, as Dr. Stanfield pointed out, it might in the first place enter the slag as sulphate. Mr. Lindstrom spoke of the removal of sulphur in the slag as manganese sulphide. He considered that the poorer quality of basic steel, as compared with acid steel, was due to the large amount of oxides (lime, etc.) which are present in the slag.

Mr. Werner gave a further explanation of the elementary reactions taking place in the steel furnace.

Mr. Spencer proposed a vote of thanks to Mr. Werner for his interesting lecture and lantern views.

## MEETING OF THE MONTREAL METALLURGICAL ASSOCIATION, JAN. 16, 1918.

Held in the Chemistry and Mining Building of McGill University, at 8.15 p.m. The President introduced the new Secretary-Treasurer, Captain James G. Ross.

The President explained that Mr. W. A. Jannsen who was to have addressed the meeting on "Steel Furnace Practice," had been detained at Ottawa and that, at an hours notice, Mr. W. G. Dauncey had kindly consented to give a talk on "How metallic iron is won from the iron ore." The talk was illustrated by lantern slides and dealt particularly with recent practice in the production of shell steel. A discussion fol-

lowed in which Messrs. Phillips, Phipps, and Roast, Dr. Stansfield and others took part.

"The speaker prefaced his remarks by stating that he hoped his audience would overlook all shortcomings and disconnections because an hour was rather short notice to have before appearing upon a lecture platform particularly when the subject chosen was so wide and comprehensive. In an effort to glance over the whole series of operations incidental to the conversion of iron-ore into merchantable iron and steel, the first consideration was the different varieties of iron-ores, and how these were mined, calcined or roasted, preparatory to being smelted in the blast furnace. The design, construction and working of a blast furnace was then described, and it was pointed out that during this operation metallic iron first made its appearance, and all the varying grades of pig-iron were enumerated. It was shown that the two extremes were "white" iron at one end and "grey" at the other; the white iron was hard and brittle, due to most of its carbon being in the combined form, and to a low silicon content; whilst the grey iron was relatively soft because the carbon was mostly in the graphitic form and the silicon content was high. It was shown that the white metal was suitable for making malleable cast iron because the combined carbon rendered it amenable to annealing and heat treatment; it is also. for specific purposes, used in the puddling furnace for the production of wrought, or malleable iron. The grey metal is used for remelting in the foundry cupola for the production of all kinds of castings that have to be used without any further treatment. The difference between American and European malleable cast iron was explained, and the production of malleable wrought iron, from pig, in the puddling furnace was shown to be a refining operation conducted in four stages:

I. Melting down stage lasting about half an hour, by the end of which most of the silicon and manganese, and a considerable proportion of phosphorous have been removed.

II. Quiet fusion, or clearing stage, lasting about ten minutes, during which the rest of the silicon and manganese, and a further quantity of phosphorus are removed.

III. The boil, which lasts nearly half an hour, during which the greater part of the carbon is eliminated, together with a further quantity of phosphorus.

IV. The balling up stage, occupying about 20 minutes, and by which time the purification, except as regards the removal of slag, has practically ceased.

These balls are then removed from the furnace, squeezed, or hammered, and then rolled for the production of malleable, or merchant bars. For higher grades of wrought iron these bars are cut into short lengths, piled into bundles, reheated and further rolled.

To produce crucible steel, specially selected metal is placed in a crucible and after being melted down is what is technically termed "killed." This means that the fused metal is allowed time to become quiet, otherwise the resultant casting would be unsound and full of blow-holes. The production of Bessemer steel is carried on in a converter constructed so that air may be forced through the molten metal it contains, but the process is gradually being replaced by the open-hearth methods. By the open-hearth process steel may be produced in larger quantities than by any other; the furnace consists of a rectangular basin-shaped hearth with a tapping hole situated at the lowest point, and inlet and outlet ports at either end. Such furnaces are worked on the regenerative principle, that is combustion of the fuel takes place at one end, does its work passing over the hearth, and then escapes from ports at the other end. After leaving the furnace proper the flame and products of combustion are passed through regenerative chambers, packed with a net work construction of fire-bricks, and here give up the major portion of their heat before being allowed to escape to the stack. By an arrangement of valves the direction of these products of combustion can be changed from one end to the other, and it is this adaptability that introduces the regenerative principle. Having run for about half-an-hour in one direction the valves are reversed and what were the ingoing set of regenerators, valves, and ports, are now made the out-going. The supply of air necessary for combustion has now to pass over the heated network of fire-bricks and in doing so takes up the heat stored there by the previously out-going gases and a consequent increase in temperature takes place. This air now carries part of the heat back to the furnace hearth from whence after doing its work it is allowed to escape through the opposite set of regenerators. The operation thus becomes an alternating one, first heat is stored in a regenerator then taken back to the furnace and afterwards restored in the opposite regenerator. By this system it is possible to work with higher temperatures than would otherwise be obtainable. Both acid and basic steel is produced is an open-hearth-furnace the difference being in the lining of the furnace and the materials used to make up the charge. For acid work silica brick and sand are used for the hearth, but for basic production these materials are unsuitable owing to chemical actions that would arise, and it is therefore usual to rely upon a magnesite lining. By the acid process phosphorus and sulphur are not removed and as a consequence no more of these elements must be present in the raw materials than is permissible in the finished steel; but with basic practice this is different, the introduction of lime as a slag forming factor rends the removal of phosphorus (and to a limited extent sulphur) an easy matter because the lime has a stronger affinity for phosphorus than has the iron. The use of lime is not possible in an acid lined furnace because its presence would immediately cause the lining to scour away. The fact that vast bodies of ore exist which yield a pig-iron containing too much phosphorus for conversion by an acid method accounts for the wonderful increase in basic open-hearth steel. The most recent method of manufacturing steel is by the electric furnace, this is sometimes used to finally purify steel melted in another furnace, or it may be used to melt and refine the charge. Whichever way it may be worked the electric production of steel has come to stay, and later on the same rema[illegible] will equally apply to the smelting of iron ores. During the present war an enormous number of blanks (ingots) have been cast in Canada for the production of high explosive shells and the chemical composition of this steel has frequently been changed. To-day the specification calls for an analysis conforming to:

| | |
|---|---|
| Carbon | = 0.45 to 0.55% |
| Manganese | = 0.70 to 1.0 % |
| Silicon | = 0.20 to 0.30% |
| Phosphorus | = 0.07% |
| Sulphur | = 0.06% |

Don't forget to fill out and return the Pink Slip — See page 32.

ALFRED STANSFIELD, D.Sc.,
Editor-in-Chief
of "Iron & Steel of Canada."

W. G. DAUNCEY, C.E., M.E.
Associate-Editor
of "Iron & Steel of Canada."

Steel to this specification is easily made providing suitable raw materials are available, but great losses have been entailed by Canadian steel makers through the Imperial Munitions Board asking for, and insisting upon having, a design and size of blank which it was impossible for the steel makers to satisfactorily produce, or which it was impossible for the forge people to convert into a satisfactory shell forging.

The speaker then sketched the various types of mould used for the production of these blanks, and showed how from the original parallel walled open bottom had gradually been evolved the present type of taper mould with solid base. By the use of this mould cooling conditions were controlled and "piping" below the discard was entirely eliminated, whilst rejections were reduced from about 15 per cent. to under 1 per cent. After casting these blanks 20 per cent. is removed from the top as discard and the remainder, after rigid inspection, is utilized to form the forging. The construction and capacity of the hydraulic presses used for forging shells was described, and the actual size and shape of 6, 8 and 9.2 inch shells was given.

Mr. Dauncey also outlined the specific duties of chemists and metallographers and showed that whilst of the greatest mutual assistance their method of operation was diametrically opposed; the chemist had to destroy before he could give results, whilst the metallographer studied his sample as it originally existed and could retain it for future reference. In conclusion the speaker highly complimented Canadian manufacturers upon the way they had handled the production of munitions and ventured to predict a big boom in the iron and steel industry during the next ten years, as enormous quantities would have to be produced to replace bridges, ships, rails, and rolling stock. Canadian natural resources would have to be developed to the utmost, the new business competition would have to be met, and all round education was going to be one of the most potent factors.

He could not too strongly urge the younger men to devote time to the study and investigation of the inner meaning of the operations they were employed upon.

In answer to questions Mr. Dauncey dealt with the operation of case-hardening and pointed out its importance, especially to the motor trade, and at the same time indicated that case-hardening and heat treatment generally were most promising fields for further research.

# A New Electric Furnace

At a meeting of the Faraday Society[1], held in London, on November 7th, 1917, some interesting papers were presented with reference to the production, control and measurement of high temperatures.

The first paper, by E. F. Northrup, describes a new electric furnace suitable for melting metals. This furnace employs an entirely new method of applying electrical heat to this purpose, and it is desirable to compare this with the methods at present in use. The new furnace is not like the ordinary steel furnace in which heat is produced by means of electric arcs, but is a furnace in which brass or other metals can be melted in crucibles protected from the air, and if necessary even in a vacuum.[2]

The simplest type of electric furnace for crucible melting is shown in figure 1, and consists of a coil of wire A, composed preferably of nichrome, surrounding the crucible B in which the metal is to be melted and contained within an outer jacket C for retaining the heat. This arrangement is very suitable for small scale operations when the temperature to be reached is not very high. It is limited in the first place by the melting point of the wire, which should not be heated above about 1,280° Centigrade (2,340° Fahrenheit); and with regard to the efficiency of this furnace it is pointed out that although at the beginning, by making the crucible thin and the outer walls thick, nearly all the heat will pass inwards into the crucible and very little will be lost, yet when the crucible has reached nearly to the temperature of the coil the flow of heat inward becomes small in proportion to the flow of heat outward, and therefore the efficiency becomes very low. A better arrangement is shown in Figure 2, which represents in plan a similar furnace in which the heat is produced in a number of carbon plates AA, through which the electric current passes; being supplied by means of the electrodes EE. In this furnace a much higher temperature can be obtained since carbon can be heated to a temperature of 3,600° Centigrade (6,500° Fahrenheit) without melting. The efficiency of the furnace will therefore be very much greater on account of the higher temperature of the carbon heaters, and the only practical limit is imposed by the difficulty of finding a sufficiently refractory jacket C for the furnace. In Figures 1 and 2 the heat is produced in a heating element of wire or carbon, and is conducted from that through the crucible to the metal to be heated. The ideal method would be to supply

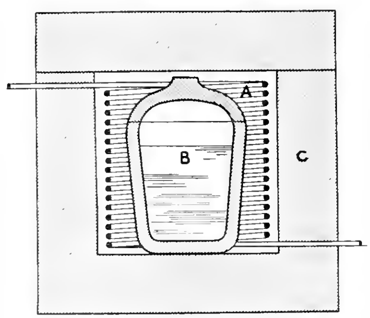



*FIG. 1*

**Crucible furnace with wire heater.**

[1]Metallurgical and Chemical Engineering, Dec. 15, 1917, p. 685.

[2]Following cuts are merely diagramatic and do not represent exactly the construction.

the heat within the metal itself. This has been done in the induction furnace for melting steel shown in Figure 3. This consists of a circular channel BB containing the molten steel. This channel is made the secondary winding of a transformer, D being the primary winding, and F being the magnetic circuit. In this furnace an alternating current is supplied to the primary

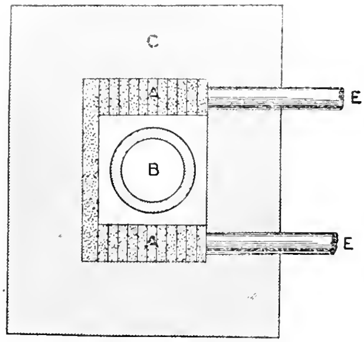



*FIG. 2*
**Crucible furnace with carbon heater.**

winding D, and a very much larger secondary current at low voltage flows in the steel channel B. This arrangement offers the advantage of producing the heat directly in the metal that is being melted; but it is essential that a complete ring of molten metal should be placed in the furnace for a start, and the crucible is necessarily of a very inconvenient and extended

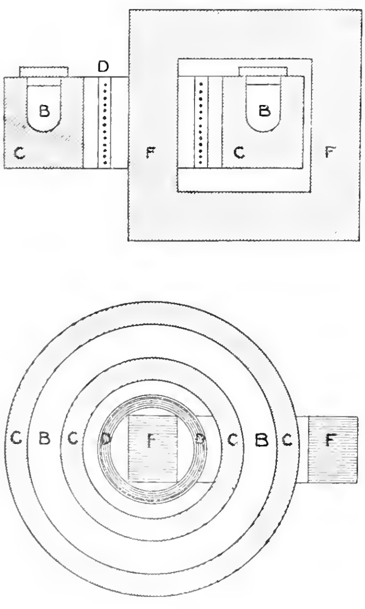



*FIG. 3*
**Induction furnace for melting steel.**

form; while a magnetic circuit, consisting of iron, must be looped through the primary and secondary circuits of the transformer. A further trouble is caused by the fact that with these furnaces the power factor of the electric current is so low as to interfere materially with the operation. All these considerations detract very seriously from the practical value of the induction furnace as a melting apparatus.

Mr. Northrup has, after extended work, been able to design a furnace of a crucible type in which the heat can be generated directly in the metal to be melted. This is shown in Figure 4.* The furnace consists of a crucible B with a heat retaining jacket C,

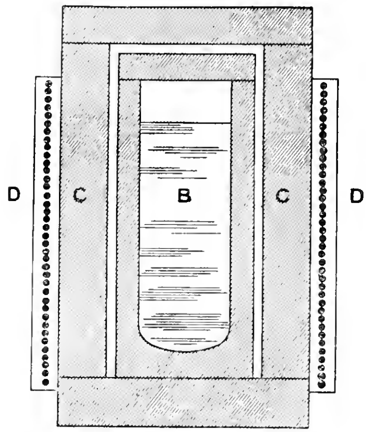



*FIG. 4*
**Northrup induction furnace.**

and an outer winding D for carrying the primary current. It will be seen that we have here an induction furnace of the simplest type, and without any iron core. The invention depends on the use of high frequency, high voltage current in the outer winding; this being obtained by means of adjustable reactances, high tension transformers, electrical condensers and a new type of discharge gap. At present the largest furnace is of 20 kilowatts capacity, but furnaces of fifty and sixty kilowatts are shortly to be constructed. The following results have been obtained with the twenty kilowatt furnace:

[3]1. "It operates on a two-phase circuit, drawing an equal load from each phase.

2. "It operates at full load with unity power factor for the supply circuit or with a slightly leading current.

3. "It operates at any small fraction of full load with appreciable reduction in efficiency.

4. "The metal-melting furnace will melt, starting at room temperature, about 45 lb. of brass in thirty-five minutes when watt-hour meters in the supply mains register a total power supplied of 18 kw.

---

*It must be understood that this figure is merely diagramatic as full information about the construction is not available.

[3]Metallurgical & Chemical Engineering, Dec. 15th, 1917, pp. 686-7.

5. "The vacuum-type furnace will bring a crucible of Acheson graphite 14 cm. in diameter and 18 cm. high, filled with tin or glass, to a temperature of well over 1600 deg. C., in forty to fifty minutes, and a vacuum of not less than 1 cm. of mercury can be maintained during the process. It should be stated, however, that certain kinds of glass evolve a vapor under reduced pressure which diminishes the vacuum and makes the glass frothy.

6. "Cylinders or crucibles of the above dimensions or smaller, made of graphite can be raised to a temperature of 1600 deg. C. with an almost perfect uniformity in their temperature distribution. Cylinders of other materials, as of iron, nickel, or nichrome may be raised in temperature until they start to melt.

7. "The thermal efficiency, defined as the ratio of heat energy developed within the crucible and its contents to kilowatt hours supplied at switch terminals (both expressed in like units), may be made as high as 60 per cent. with the 20-kw. furnace illustrated, and it is thought that a greater thermal efficiency may be obtained in a furnace of larger power capacity.

"The melting of platinum in vacuum has not yet been accomplished, but it is expected that this result will be attained when certain required devices have been constructed."

"The furnace described has been operated at 5400 and at 7200 volts at the condenser terminals. The frequency is the natural period of the oscillatory circuit of either phase. About equally good results have been obtained when working with 25,400 cycles and with 12,500 cycles per second.

"Protection from the high voltage is secured by surrounding the furnace casing with a grounded metal cage, and the crucible, in addition to being electrically insulated from the inductor coil with a cylinder of quartz glass, is likewise grounded."

"This furnace was developed by Mr. Northrup for, and with the financial support of, the Ajax Metal Company, of Philadelphia, Pa. The development was made in, and with the facilities of the Palmer Physical Laboratory of Princeton University.

"The early construction of furnaces of larger kilowatt capacity is under contemplation. These furnaces should be particularly adapted to the melting of optical glass, high melting alloys, brass, gold, silver, etc."

# Pyrometry and Temperature Control

The paper of Mr. E. F. Northrup, referred to above, contained also an account of recent developments in the measurement of high temperatures. Furnace temperatures are frequently measured by pyrometers of the thermo-electric type, which consists of two wires or rods of different metals joined together at one end, which is inserted in the furnace, while the other end is connected to some measuring instrument. With this use of the pyrometer there are liable to be certain errors caused by changes of resistance of the thermocouple or connecting wires, and to get over these and certain other difficulties a new instrument—the pyrovolter—has been brought out by the Pyroelectric Instrument Company, which enables the electro motive force generated by a thermo-couple to be accurately measured. The paper describes the construction and electrical arrangement of this appliance. One of these instruments is in use in the Metallurgical Laboratories of McGill University and has been found entirely satisfactory.

Mr. Northrup also described a new appliance resembling a mercury thermometer for use at high temperatures, but the mercury is replaced by molten tin, and the glass by Acheson graphite. The thermometer consists of a bulb, or tube, made of graphite and filled with molten tin—a stem, also made of graphite, up which the tin expands with rise of temperature, and a nickel wire arranged to make electrical contact with the tin when this expands to a certain point. This appears to be suitable for regular use for the measurement of furnace temperatures, but as yet it has not been tried out in industrial operation.

Mr. R. P. Brown, of the Brown Instrument Company, describes "a new heat meter for use with thermo-electric pyrometers." This meter is somewhat similar in principle to the pyrovolter already referred to. Mr. Brown also points out the possibilities and advantages of automatic temperature control of furnaces. This can be managed by means of electric pyrometers, placed in the furnace, which are arranged to operate a relay system if the temperature becomes too high or too low. The relay ultimately controls electric switches if the furnace is an electric one, or valves if the furnace is heated by gas or oil. In this manner furnaces can be kept at a more steady temperature than by hand regulation, with the added advantage of lessening the cost of operation. The details of this system are too elaborate to reproduce here, and reference should be made to the original paper. It is intended, however, in later issues to take up more fully the general subject of pyrometry and furnace control.

### STUDY OF REQUIREMENTS.

We are always glad to hear of results obtained from a special study of the requirements of customers, and we think more might be done along this line.

We cite as an instance of this, Wilkinson & Kompass, of Hamilton, with branches at Toronto and Winnipeg, who have made a special study of the Iron and Steel requirements of the country, and have noted particularly the increasing need of Canada for heavy iron and steel. They have accordingly armed themselves with an extremely wide range of sizes, and have also put themselves in a position to turn out promptly bar forgings up to any size.

They report that the results of this policy have been most gratifying and that their business in this direction has increased very considerably.

**Don't forget to fill out and return the Pink Slip — See page 32.**

## A PLEASANT FAREWELL.

On Saturday, January 26th, a very pleasant social gathering was held at Montreal in the form of a farewell dinner tendered to Mr. W. G. Dauncey, upon his resignation from the position of consulting metallurgist to The Canadian Steel Foundries. The guests were limited to superintends of the various plants and those who had been most closely associated with Mr. Dauncey during the two years of his connection with the company. The various speakers unanimously credited Mr. Dauncey with having designed the only satisfactory six, eight, and nine point two inch blanks for high explosive shells, and congratulated him upon the fact that his work was now accepted as standard both in Canada and the United States. In his reply Mr. Dauncey pointed out that it would have been impossible for him to perfect these blanks but for the wholehearted support and co-operation afforded him by the superintendents and staffs engaged at the various plants.

The future development of natural resources, particularly those affecting the Iron and Steel trades, were dealt with and in conclusion the speaker warmly thanked the hosts for the compliment they had paid him and also for all the good wishes that had found expression during the evening.

---

In the December report of the Proceedings of The Steel Treating Research Society, Mr. J. L. Thorne (Thorne Steel Treating Company) publishes an interesting and instructive paper on "The evolution of a High Speed Steel Tool." The author prefaces his remarks with the statement that "It is a long step from a piece of soft reddish brown iron ore to a finished High Speed cutter, or drill, and yet they are the beginning and the end of the highest pinnacle of the toolmakers art. He then deals with historical matter and passes on to the crucible process by which so much high grade steel is produced. The alloying elements, Tungsten, Vanadium, and Chromium, with others whose influence is not so well established are mentioned. He defines High Speed Steel, gives microphotographs of high magnification, to illustrate ingot structure and also specimens of good and poor annealing practice, and argues strongly in favor of oil-fired furnaces for all heat-treating operations. The paper is exhaustive and should be perused by all interested in the quality and service of High Speed Steels.

Two other papers also appear in this publication and should be read in conjunction; one deals with "Pyrometers and their application to the Steel Industry (by Mr. Claud S. Gordon) and the other one with "The Automatic Control and Measurement of High Temperatures" (by Richard P. Brown).

With the rapid advance in the Heat Treatment of steel these papers both come at an opportune time, and from all indications these Steel Treating Research Clubs are doing, and will do an ever-increasing service to those engaged in securing the best physical results from all grades of steel.

---

Like other organizations the Steel Company of Canada is being affected by the shortage of coke. One blast furnace which was producing foundry pig has been banked, but the other is running on basic metal. The acute coke situation justifies the policy of the firm in building its own coke ovens, but these cannot be ready in time to relieve the present shortage.

## SHIPBUILDING IN CANADA.

We are authorized to state that The Canadian Car & Foundry Company have undertaken a contract for building twelve steel mine sweeper vessels for the French navy, which they intend to build at their Fort William, Ontario, plant. We understand the contract price aggregates approximately $2,500,000.00, and we hope to be in a position to give full particulars of this interesting event in our next issue.

---

W. H. Banfield and Sons, 372 Pape Avenue, Toronto, are about to let contracts for the erection of a new foundry at Toronto.

---

We understand that in experimenting with powdered coal as a fuel for malleable iron annealing ovens, using a good grade of Kentucky bituminous coal of 12,500 B.T.U., the ratio of fuel to iron was 1 to 3.5. If this result can be established it is probable that much of the annealing of malleable cast iron and steel will be performed with the aid of powdered coal. In regard to small plants, however, it must be mentioned that the installation is expensive, and that an element of danger is introduced in the handling and storage of this class of fuel.

---

On page 44 of the January number of "The Foundry" appears an instructive article on "A New Method of Making Shell Bands." The shell band is made by converting a flat copper ring into a band by the use of a punch and die. The ring is punched out of sheet copper, and afterwards upset by being passed through a die. The inventor describes his process as follows: " A method of making metallic bands consisting in providing a washer-shaped ring of material thickness, said ring being thinner at its outer diameter than at its inner diameter, upsetting said ring to form a cylindrical band of substantially the same thickness throughout, straightening and rolling the edges of said band and truing and straightening the walls of the band by compressing the band."

---

"The Canadian Foundryman" publishes an article entitled, "Electric Steel Manufacture in Denmark." A company has been formed in Denmark, with a capital of 600,000 kronen, for the manufacture of steel from scrap, which is being smelted and refined and a little new iron added. It is said to be the same process which the Krupp works use for the manufacture of their best guns. To commence with, the new undertaking will confine its work to the production of smaller articles, machine parts, etc., but it is proposed to extend it, ere long, also to comprise heavy ingots by the Siemens-Martin furnaces, of which so far only one has been in use in Denmark—in the Burmeister and Wain establishment. Scrap is said to be available in sufficient quantities, but up to now it has principally been exported to Sweden. The new company, consequently is fairly independent of foreign supplies, which is a very important point under the present circumstances. The undertaking is backed by several prominent men, and the installations will ultimately be on a large scale. The foundry building is two-storied, and has a length of over 100 m. Operations will commence probably by the end of November, and work is expected to be in full swing in the beginning of the new year.

**Don't forget to fill out and return the Pink Slip — See page 32.**

# The Present Position and Future of the Iron and Steel Industries in Canada

By CORBETT F. WHITTON.

Annual Meeting, Montreal, 1917.

In endeavoring to analyze the present situation of the iron and steel industries of Canada in relation to its natural mineral resources, the requirements of its home markets, and the possibilities of future expansion of these markets in Canada and abroad, it is proposed to deal with some of the facts and conditions relating to the commercial and manufacturing side of this subject, including:

1. A description of the principal Canadian iron and steel plants; an account of the sources of their ore and fuels, the cost of assembling these materials at their plants, and the facilities for transporting the products to Canadian and export markets.
2. A statement of the amount and variety of iron and steel products which are manufactured by Canadian plants, as compared with what is imported from the United States and other countries.
3. A statement of the costs of production of various iron and steel products in Canada, as compared with those in the United States. A tabulated statement of the costs of assembling raw materials and transporting finished products from Canadian and American iron and steel centres to various Canadian markets.
4. A consideration of the possibilities of increasing the variety and tonnage of steel products, manufactured in Canada, and suggestions as to possible means of fostering and protecting Canadian steel industries with a view to Canadian trade, and co-Imperial and foreign export trade.

### Canadian Plants and their Products

The principal plants making pig iron and a variety of steel products are:—

Dominion Iron & Steel Company—Sydney.
Nova Scotia Steel & Coal Company—Sydney Mines and New Glasgow.
Steel Company of Canada, Limited—Hamilton, Toronto, Montreal, and other points.
Algoma Steel Company—Sault Ste. Marie.

The principal facts relative to the plant, raw materials, and products of these companies are tabulated below:

### Dominion Iron & Steel Company.

| Iron Furnaces and Supplies. | Annual Capacity. |
|---|---|
| 6 blast furnaces of 250 G.T. capacity each per day | 550,000 G.T. basic and foundry pig iron. |
| Company owns Wabana Ore Mines, Newfoundland | 850,000 tons |
| By-product coke plant, consisting 620 ovens | 650,000 N.T. coke. |
| By-product recovery plant for Benzol, Toluol, Naphtha, Naphthaline, and Sulphate of Ammonia | |
| Plant for manufacture of cement from blast furnace slag | |
| Limestone quarries in Nova Scotia and Newfoundland | 630,000 tons. |

| Steel Works. | Annual Capacity. |
|---|---|
| 10 Basic open hearth furnaces (50-ton)<br>3 Basic Bessemer converters (15-ton) | *400,000 N.T. (Ingots used only for desiliconizing, dephosphorizing, and decarburizing molten pig iron for open hearth furnaces). |
| 35″ 2 high reversing blooming mill<br>16″ Morgan. cont. billet mill | 375,000 tons blooms, billets and slabs. |
| Morgan cont. rod mill | 90,000 tons wire rods. |
| Morgan semi-cont. rod and bar mill with 12″ roughing and 9½″ finishing trains | 60,000 bars. |
| 16″ Merchant mill | 75,000 tons bars. |
| 28″ Rail mill | 300,000 tons. |
| Wire department | 50,000 tons. |
| Wire Nails | 30,000 tons. |

### Nova Scotia Steel & Coal Company.

| Iron Furnaces. | Annual Capacity. |
|---|---|
| 1 Blast furnace at Sydney Mines of 250 G.T. daily capacity | 90,000 G.T. basic and foundry pig iron. |
| 1 New blast furnace under construction | 80,000 G.T. |
| By-product coke plant, consisting of 150 ovens | 110,000 N.T. of coke. |

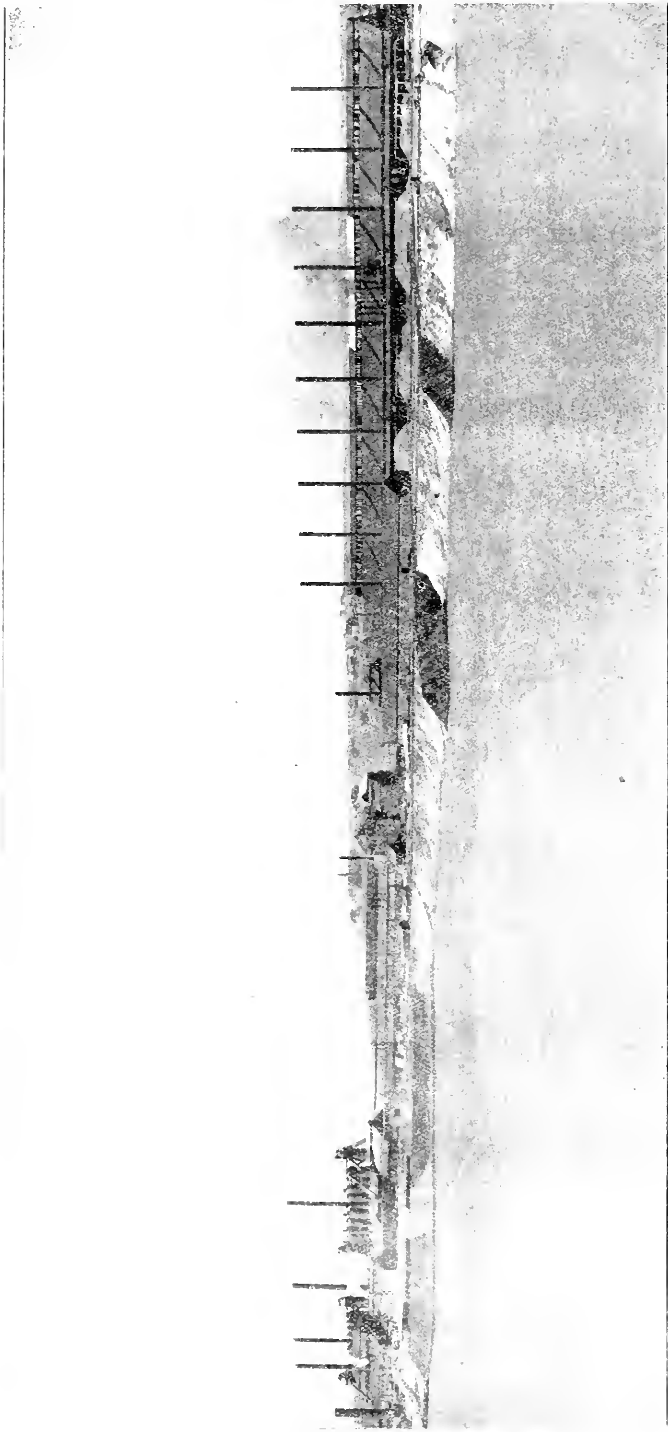
| Steel Works. | Annual Capacity. |
|---|---|
| 5 Basic open hearth furnaces at Sydney Mines | 50,000 N.T. steel and fluid compressed ingots |
| 28″ Cogging mill<br>20″ Plate mill<br>18″ and 19″ Rolling mills<br>9″ Guide mill<br>Hammer and forging presses | Total 60,000 tons of finished, rolled and forged products, including merchant bars, angle bars, tie plates, etc. |
| 2 Railway spike machines | 7,500 tons. |

| Mines. | |
|---|---|
| Ore mines at Wabana, Newfoundland | 600,000 tons. |
| Coal mines at Sydney Mines | 800,000 tons. |
| Limestone quarries in Nova Scotia | 70,000 tons. |

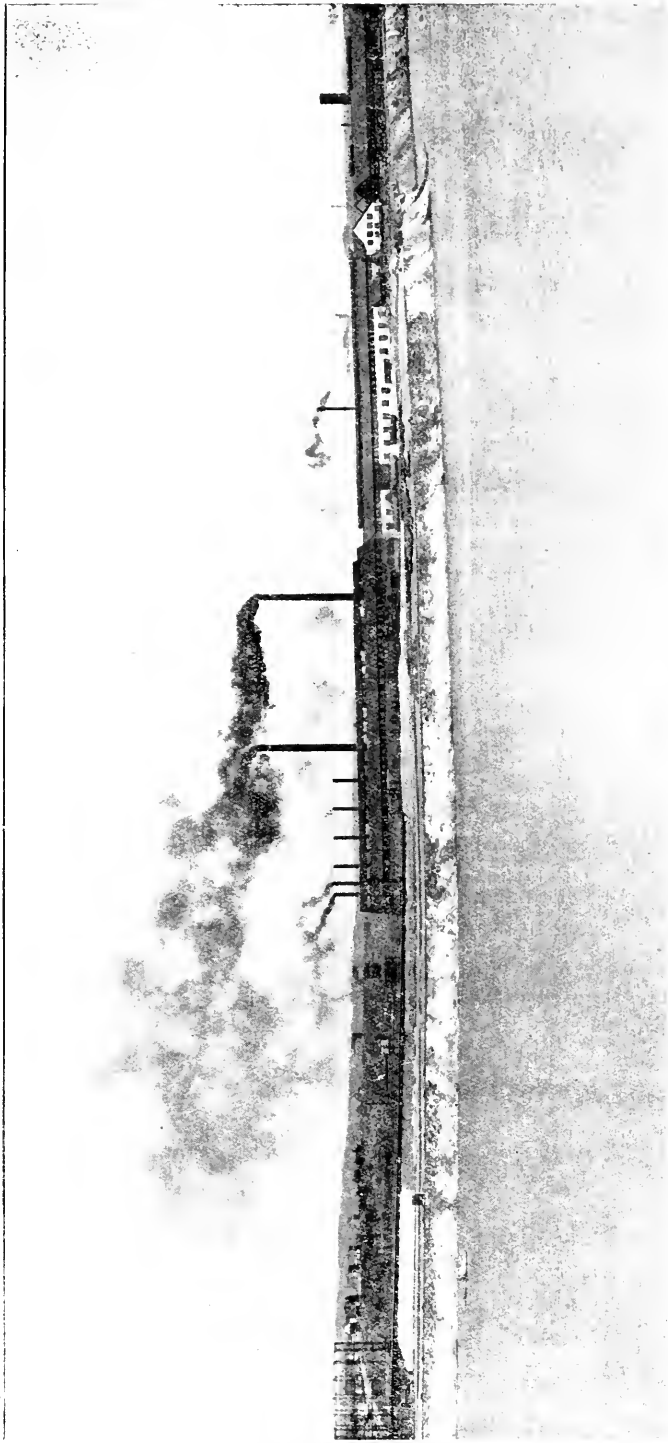
The Eastern Car Company, a subsidiary concern manufactures steel and wooden cars, car wheels, etc. It utilizes a considerable portion of the plates and bars made by the Nova Scotia Steel Co., and has important and growing facilities for steel shipbuilding. The Nova Scotia Steel Company operates a number of ocean vessels, which carry its ore and coal to export markets.

The plants of the Dominion Steel Company and the Nova Scotia Steel Co. are most favorably situated for the utilization of the enormous iron and coal resources in that territory. A large tonnage of Wabana ore is exported by these companies to Europe and the United States. These exports comprise about two-thirds of the total ore mined, the balance being used in their own blast furnaces in which pig iron is produced for conversion into basic steel, although this iron contains high percentages of phosphorus, silicon, and sulphur. The coal supply also is very well suited for coking and steam purposes. The cost of transportation

Don't forget to fill out and return the Pink Slip — See page 32.



Left half of panoramic view of Dominion Iron and Steel Company's Plant at Sydney, N.S.



Right half of panoramic view of Dominion Iron and Steel Company's Plant at Sydney, N.S.

Don't forget to fill out and return the Pink Slip — See page 32.

to these plants both of ore from Newfoundland and coal from Cape Breton mines is very low, compared with that in other important iron districts.

Both companies export a large proportion of their products, notably, rails, forgings, and wire products to the United States, England and other countries, and should be able to expand their plants so as to increase the variety and tonnage of iron and steel products for export; while their low cost of production and shipping facilities should enable them to compete for export trade with producers in the United States or Germany.

### The Steel Company of Canada.

The Company has two blast furnaces at Hamilton, Ont., of 250 and 350 G.T. daily capacity, and an annual capacity of 200,000 tons basic foundry and malleable bessemer iron. The iron ore is purchased mainly from the U.S. Lake Superior Mining Companies. Connellsville "beehive" coke is used entirely. A by-product coke oven plant is projected. Limestone is purchased from quarries within a close radius. This plant is the largest one in Canada that is entirely dependent on outside supply sources for raw materials. Ore brought from Lake Superior cannot pass through the Welland Canal at present, but is unloaded at Point Edward on Lake Huron, whence it is carried by rail to Hamilton. This involves extra expense as compared with any other blast furnace plant located on the Great Lakes, but this expense will cease after the deepening of the Welland Canal, which will allow large ore vessels to come to Hamilton.

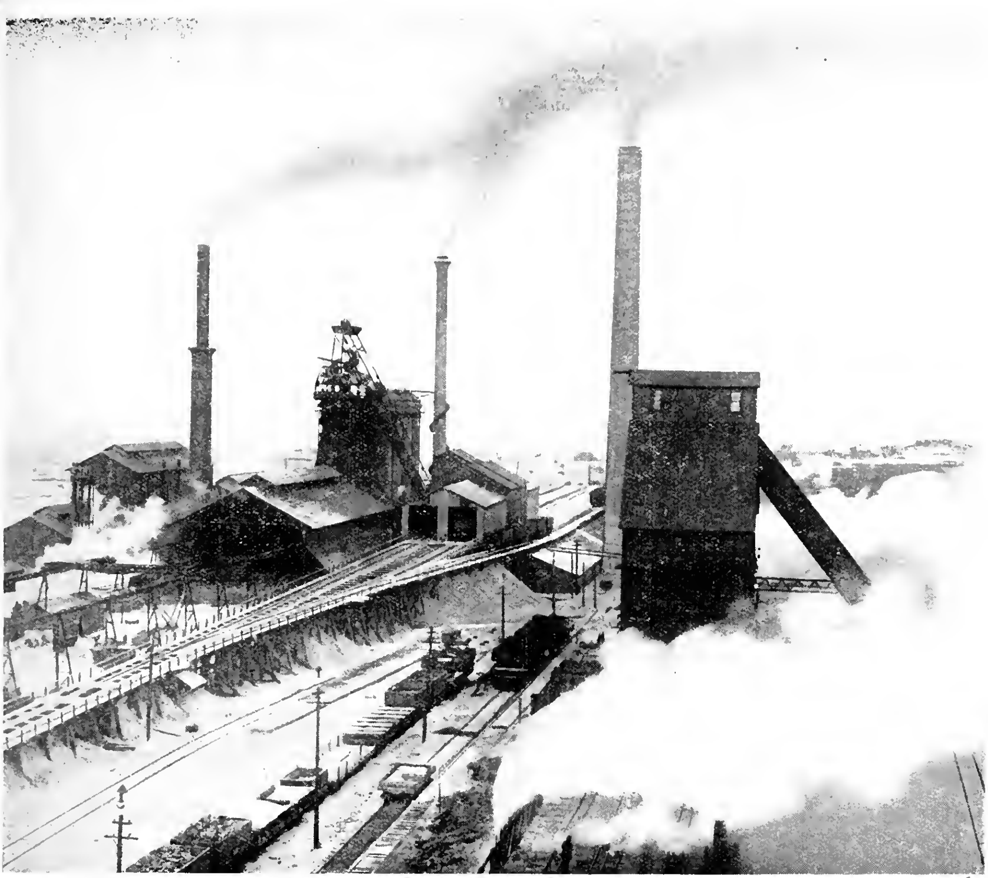
| Steel Works. | Annual Capacity. |
|---|---|
| **(Hamilton Works)** | |
| 11 Basic open hearth furnaces.. | 400,000 N.T. ingots. |
| 34″ Reversing blooming mill.... | 350,000 tons blooms and billets. |
| 18″ Morgan cont. billet mill.... | |
| Morgan cont. combination rod and bar mill .............. | 100,000 wire rods |
| 14″ and 10″ Bar mills.......... | 40,000 merchant bars. |
| 3 Railway spike machines...... | 10,000 tons spikes |
| 6″ Mill sheet plant ........... | 40,000 tons sheets. |
| **(Ontario Works)** | |
| 20″ Bar mill ................. | 100,000 tons of merchant bars, angle bars, tie plates, etc., including a certain proportion of iron bars. |
| 10″ Bar mill .................. | |
| 9″ Guide mill ............... | |
| Car and locomotive axle department ..................... | |
| Heavy shape forge department.. | |
| **(Canada Works, Hamilton)** | |
| Wire department . . ........... | 25,000 tons. |
| Wire nail department ......... | 240,000 kegs. |
| Other finishing departments are: | |
| Tacks, wood screws, machine screws, bolts, nuts and rivets. | 3,500 tons. |
| **(Belleville Works)** | |
| 18″ Muck mill ................ | 30,000 tons iron and steel bars, merchant bars and horse shoe bars. |
| 12″ Bar mill .................. | |
| 9″ Bar mill .................. | |
| Horse shoe department......... | 50,000 kegs. |
| Spike department .............. (2 Hand spike machines) | 20,000 kegs pressed, ship, drift and railway spikes. |
| **(Montreal Works)** | |
| 18″ Muck mill ................ | Products, bar iron and steel, horse shoe bars, angle bars ,nail and washer plate. |
| 18″ Bar mills (2) ............. | |
| 12″ Merchant mill ............ | |
| 12″ and 9″ Belgian mills (2).. | 60,000 tons. |
| Other finished products are:— | |
| Horse shoe department ........ | 110,000 kegs. |
| Wire department .............. | 30,000 tons. |
| Wire nail department ......... | 275,000 kegs. |
| Horse nail department ........ | 30,000 boxes. |
| Cut nail department ........... | 30,000 kegs. |
| Bolt and nut department ....... | 130,000 kegs bolts, nuts, rivets, washers, etc. |
| Spike department ............. | 55,000 kegs pressed and railway spikes. |
| Pipe mills, ¼″ to 4″ butt-weld pipe, black and galvanized couplings and nipples. ........ | 25,000 tons. |
| **(Dominion Works)** | |
| Wire department .............. | 25,000 tons . |
| Wire nail department ......... | 125,000 kegs. |
| Other products are:— | |
| Woven wire, fence, gates, barbed wire, bale ties, wire cable.. | 10,000 tons. |
| **(Brantford Works)** | |
| Bolt and nut department........ | 10,000 kegs of bolts, nuts and rivets. |
| **(Swansea Works)** | |
| Bolt and nut department........ | 90,000 kegs of bolts and nuts. 10,000 kegs of rivets. |
| **(Gananoque Works)** | |
| Forge department ............. | Carriage and carriage top hardware, auto and miscellaneous vehicle forgings. |
| **(London Works)** | |
| Wire and nail department ..... | 36,000 kegs wire nails. |

In order to manufacture such a variety of products, a considerable tonnage of rolled iron and steel in the form of bars, wire rods, nut flats, horseshoe bars, plate, etc., which are included in the total output, are used for further conversion in finishing departments and are not sold in the shape of rolled products. While among Canadian undertakings the Steel Company of Canada is only the third largest producer of steel ingots, it produces the greatest quantity and variety of manufactured steel products, such as foundry pig iron, bars, horseshoes and nails, pipe, spikes, wire of all kinds, wire nails, tacks, rivets, bolts, nuts, washers, wood screws and wire goods. Many of these articles are manufactured in Canada, solely by this company, and are imported only in small quantities. The company operates plants in eight different cities from Fort William to Montreal, and has exceptional facilities for supplying at a low delivery cost the large markets in Ontario.

### Algoma Steel Corporation.

| Blast Furnaces, Etc. | Annual Capacity. |
|---|---|
| 3 Blast furnaces: | |
| 2 of 250 G.T. daily capacity.. | 350,000 G.T. Bessemer and basic pig iron. |
| 1 of 450 G.T. daily capacity.. | |
| By-product coke made from coal transported by lake steamer from American lake ports. 110 ovens ................. | 432,000 N.T. |
| By-product recovery plant and sulphuric acid plant ......... | |

The company owns the Helen and Magpie mines situated about 11 miles north of Michipicoten Harbour. The Helen mine produces hematite ore, averaging about 55 per cent iron. The Magpie mine produces siderite ore which after roasting yields about 50 per cent of iron. When market and mining conditions



**Blast Furnace and Coke Ovens of the Nova Scotia Steel & Coal Co., Ltd., Sydney Mines, N.S.**

The tracks in the centre of the picture run over the top of the coke ovens. When red hot coke has been drawn from the ovens it is cooled by streams of water from hose. The clouds of steam seen in the foreground have been caused by this operation.

warrant, a certain tonnage of ore from these mines is sold to other furnaces in Canada and in the United States. The company also owns several undeveloped iron ore deposits; extensive coal properties in West Virginia, producing 6,000 tons per day; and limestone properties in the neighborhood of Sault Ste. Marie.

| Steel Works. | Annual Capacity. |
|---|---|
| 10 Basic open hearth furnaces.. | 400,000 N.T. |
| 2 (5-ton) Bessemer converters. | 270,000 tons, formerly used for duplexing now dismantled. |
| 1 (20-ton) Bessemer converter. | 180,000 N.T. |
| 1 (200-ton) Basic tilting furnace, for duplexing ........ | |
| 35″ Reversing blooming mill | |
| Rail mill .................... | 350,000 tons. |
| 18″ and 12″ Merchant mills producing light rails and structural shapes, splice bars, tie plates and merchant bars..... | 105,000 tons. |
| Bolt and spike department for railway spikes, bolts and nuts | |

The Algoma Steel Corporation is very well equipped for producing a large tonnage of rails and rail fastenings,as well as bars and light structural shapes. The favorable situation of the works in respect of ore supplies and of water shipping facilities has enabled the company to market a considerable tonnage of rails in the United States in competition with the largest American producers. The position near the head of the Great Lakes, affords access to markets of the Northwest and Pacific coast, as well as to Lake Ontario and Eastern points on the St. Lawrence.

The tonnage of light structural shapes rolled is only a small proportion of the total Canadian consumption, but the company could enlarge its plant for the manufacture of heavier structural shapes and plates for which there is a large market in Ontario and Western Canada.

**Don't forget to fill out and return the Pink Slip — See page 32.**

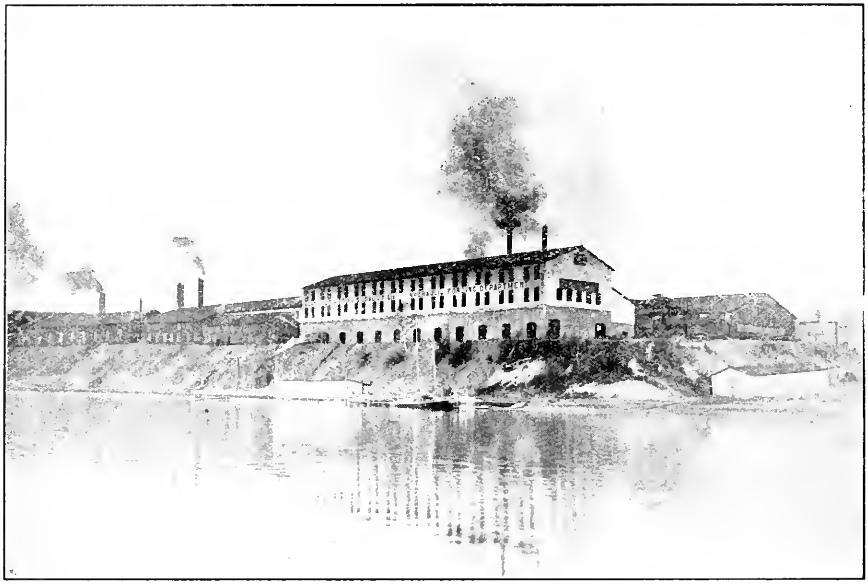
### The Canadian Furnace Company.

The company, which produces foundry pig iron for the Canadian foundry trade, has one blast furnace of 350 G.T. daily capacity, and an annual capacity of 125,000 tons of foundry, malleable and basic pig iron.

### The Iron Industry in the United States.

In comparison with the Canadian plants, the physical and economic position of the principal iron and steel producers in the United States which import an enormous tonnage into Canada, may be considered briefly. The iron industry in the United States leads the world in respect of its natural resources, shipping facilities, and design and efficiency of iron and steel making plants. The U.S. Steel Corporation, which is the largest producer of iron and steel, has played an important part in the development of the export steel trade of the United States, and there are a large number of independent concerns which successfully compete with that Corporation in both domestic and export markets. The Corporation and mostly all of the other iron and steel producers control enormous quantities of ore and coal, which they mine and transport to their plants at a cost considerably below that which must be paid by smaller concerns which purchase their supplies.

We fortunately have very complete and reliable information as to the cost, covering a period of years of 1910, of ore, coke, pig iron, and the various steel products of the United States Steel Corporation; except that allowance must be made for the improvement in methods of manufacture and equipment during recent years, other conditions have not materially changed in the interim; hence present day costs are no doubt considerably lower than ten years ago. The capacity of blast furnaces, open hearth furnaces, and all types of rolling mills of recent design are from 50 per cent to 100 per cent greater than of plants built ten to fifteen years ago. This expansion and development of modern plants in the United States has been made possible by the rapidly growing consumption of their products at home and abroad. As is clearly indicated by the growing volume of imports of iron and steel in the last five years, Canadian industries have not been able to keep pace with the expansion of Canada. Records show moreover that Canadian plants have not increased the variety of their products to any great extent even in recent years, and this is principally due to the fact that they had some protection for the products which they had been making for years; but with regard to new and unprotected products, they were dubious of being able to meet the competition of the United States in Canadian markets. That this fear has been well grounded can be proved by a comparison of the production of Canadian mills for a few years past with their productive capacity. In the circumstances it is evident that there has been no possibility of Canadian producers engaging in export trade, except at rare times when high prices have enabled the steel plants located on the Atlantic seaboard, whose cost of production is considerably lower than at works elsewhere in Canada, to find a market for a portion of their products in foreign countries.



Plant of Nova Scotia Steel & Coal Co., Ltd., New Glasgow, N.S.

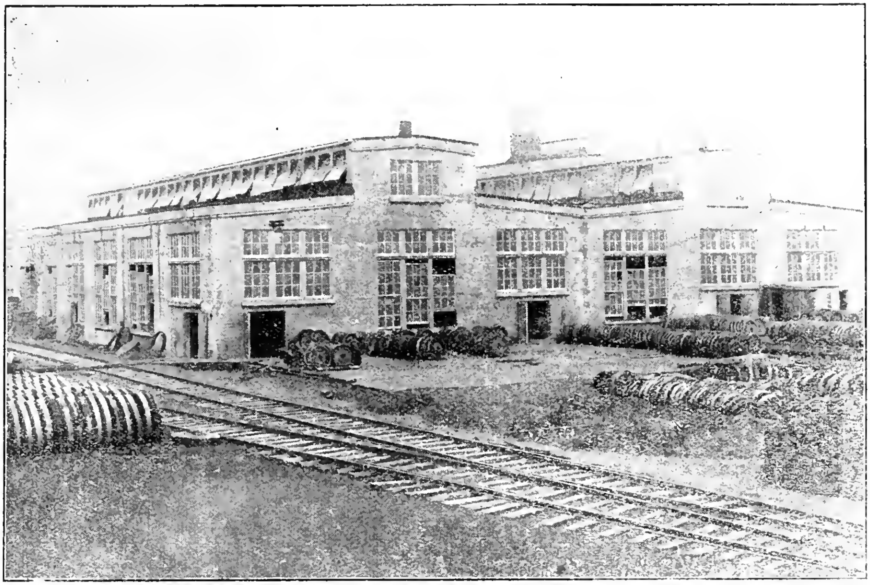
Don't forget to fill out and return the Pink Slip — See page 32.

### Canadian Productions and Requirements of Iron and Steel.

The foregoing figures enable comparisons to be made between the total production by Canadian plants of various classes of iron and steel products, and the total consumption in Canada, represented by the sum total of the production and the imports, less the exports.

### Pig Iron.

The following table shows the amount of the production, imports, and consumption of pig iron in Canada, and compares the production with the consumption and with the producing capacity of the Canadian plants:



Foundries of Eastern Car Co., Ltd., New Glasgow, N.S.

**Total Pig Iron Used and Produced in Canada in Gross Tons.**

| | Production. | Imports. | Less Exports. | T'l of Used. | P.c. of Used. | Capacity. | Prod. % of Capacity. |
|---|---|---|---|---|---|---|---|
| 1911 | 824,368 | 186,300 | ...... | 1,010,668 | 70 | ......... | .... |
| 1912 | 912,878 | 244,000 | ...... | 1,156,878 | 77.7 | 1,240,000 | 74 |
| 1913 | 1,015,118 | 211,500 | ...... | 1,226,618 | 74.8 | 1,340,000 | 78.2 |
| 1914 | 705,972 | 70,300 | 12,300 | 764,000 | 92.3 | 1,460,000 | 48.5 |
| 1915 | 825,420 | 42,350 | 15,450 | 852,320 | 96.7 | 1,460,000 | 56.5 |
| 1916 | 1,043,978 | 51,900 | 20,800 | 1,075,078 | 97.2 | 1,460,000 | 71.5 |

It will be noted that the maximum production in the year 1913 was only 78.2 per cent of the total capacity of Canadian blast furnaces, while in the year 1914, the production amounted to only 48.5 per cent of the total capacity. In other years the range is between these two limits. As in consequence of the conditions the operation of furnaces is limited to less than 70 per cent of their capacity, it is practically impossible to reduce the cost of production of pig iron to a low and uniform basis; for as will readily be understood furnaces operating continuously at their normal capacity are able to show minimum costs, while, under reduced operations, costs will increase nearly in the inverse ratio of the percentage of capacity at which they are operating.

Although these conditions apply to the total production of pig iron of all kinds including, basic, bessemer, foundry, and other miscellaneous iron, it should be pointed out that practically all Canadian steel works produce sufficient pig iron for the manufacture of open hearth and bessemer steel made in their plants, and the imported pig iron is therefore principally of the foundry grade.

A comparison of the production, imports, and consumption of foundry pig iron in Canada affords a still more striking illustration of the position of Canadian makers. The figures are presented in the following table:

**Foundry Pig Iron in Gross Tons.**

| | Production. | Imports. | Total Used (Export Incl.) | Production P.c. of Used |
|---|---|---|---|---|
| 1911 | 190,324 | 186,300 | 376,624 | 43.5 |
| 1912 | 194,208 | 244,000 | 438,208 | 44.4 |
| 1913 | 225,231 | 211,500 | 436,731 | 51.7 |
| 1914 | 174,346 | 70,300 | 244,646 | 71.3 |
| 1915 | 125,769 | 42,350 | 168,119 | 75.0 |
| 1916 | 164,501 | 51,901 | 216,402 | 76.1 |

The percentage of Canadian foundry pig iron produced in relation to the total domestic consumption has ranged in the last six years from 43 per cent to 75 per cent. The latter represents the proportion in 1915, when the total consumption of the country had fallen to a very low limit and the Canadian producers were therefore forced to market their product even at prices prohibiting a profit, or else face the alternative

Don't forget to fill out and return the Pink Slip — See page 32.

of suspending furnace operations. The normal capacity of furnaces making foundry pig iron is not known, but it may be assumed safely that there are only two furnaces (one having been in operation only since the year 1913) of which the total annual capacity is about 245,000 tons a year. On this basis the maximum rate of production, attained in 1913, was only 92 per cent of their capacity, but as in years of maximum production, prices are generally profitable enough for steel makers' blast furnaces to be used for making foundry iron for sale, the production was probably not more than 80 per cent of the capacity thus enlarged.

The duty on pig iron is of considerable importance both to makers of foundry pig iron and of steel products made by the straight Bessemer or duplex processes, as one ton of iron is used per ton of steel produced, while in the straight open-hearth process from 40 per cent to 70 per cent of pig iron is used in combination with scrap. Bessemer steel plants have been mainly converted into duplex plants, whereby basic iron is used, being first partly purified in the Bessemer Converter, and the final stage of conversion into steel performed in the open hearth furnace. About one ton of iron is used by this method per ton of steel produced. The process is more rapid than the straight open hearth, but can only be carried out economically when cost of pig iron is relatively low and scrap high.

**Ontario.**—The six coke furnaces now in operation have capacities as follows:—

| | Furnaces Number. | Daily Capacity. | Annual Capacity. |
|---|---|---|---|
| Algoma Steel Co...... | 3 | 250, 250 and 450 | 350,000 G.T. |
| Canadian Furnace Co.. | 1 | 350 | 125,000 G.T. |
| Steel Co. of Canada.. | 2 | 250 and 350 | 200,000 G.T. |
| Total annual capacity .................. | | | 675,000 G.T. |

In addition, there are the following furnaces which have not been in blast or operated continuously for some time:

| | Furnaces Number. | Daily Capacity. | Annual Capacity. |
|---|---|---|---|
| Can. Iron Found. Ltd.. | *2 | 125 and 250 | 125,000 G.T. |
| Atikokan Iron Co., Ltd. | 1 | 125 | 45,000 G.T. |
| Standard Iron Co..... | 1 Charcoal | 65 tons | |

| | Production of Pig Iron—All Grades. | % Installed Capacity. |
|---|---|---|
| 1912............ | 527,000 G.T. | 75 |
| 1913............ | 586,500 G.T. | 80 |
| 1914............ | 497,500 G.T. | 61 |
| 1915............ | 450,200 G.T. | 55 |
| 1916............ | 624,300 G.T. | 92.5 |

* The largest furnace has been bought and moved to the Algoma Steel Company plant.

This tonnage was divided as follows among the different grades:

| | Basic & Bessemer. | Foundry & Malleable. |
|---|---|---|
| 1912..... .... | 322,800 | 194,200 |
| 1913........ . | 361,300 | 225,200 |
| 1914............ | 323,200 | 174,300 |
| 1915............ | 324,400 | 125,800 |
| 1916............ | 442,600 | 181,700 |

**Nova Scotia**:—There are now seven furnaces in operation, having capacities as follows:—

| | Furnaces Number. | Daily Capacity. | Annual Capacity. |
|---|---|---|---|
| Dom. Iron & St. Corp. | 6 | 250 G.T. each | 550,000 G.T. |
| N.S. Steel & Coal Co. | 1 | 250 G.T. | 90,000 G.T. |
| Now building ...... | 1 | 225 G.T. | 80,000 G.T. |
| Total annual capacity ............ .... | | | 640,000 G.T. |

**Production of Pig Iron by Grades:—**

| | Basic and Bessemer. | % Installed Capacity. |
|---|---|---|
| 1912............ | 380,000 G.T. | 70 |
| 1913............ | 428,600 G.T. | 71 |
| 1914............ | 203,000 G.T. | 32 |
| 1915............ | 375,200 G.T. | 58 |
| 1916............ | 419,700 G.T. | 66 |

Practically no foundry iron has been made in Nova Scotia, except a small tonnage at irregular intervals. Exports of pig iron have amounted to about 4,000 tons in 1914; 17,300 tons in 1915; ;and 20,800 tons in 1916, mostly from Nova Scotia.

### Steel Plants.

Most of the important plants producing steel ingots and castings by the bessemer, open hearth, and duplex systems have been described before, and the chief point of interest in connection with the present discussion is the growth of the open hearth and electric steel producing capacity of the country during the last two years.

**Production of Steel Ingots and Castings in Gross Tons.**

| | Open Hearth. | Bessemer. | Other Kinds. | Total. |
|---|---|---|---|---|
| 1912........ | 645,062 | 207,569 | 400 | 853,031 |
| 1913........ | 768,663 | 273,391 | 449 | 1,043,503 |
| 1914........ | 556,910 | 186,158 | 284 | 743,352 |
| 1915........ | 884,736 | 22,521 | 5,498 | 912,755 |
| 1916........ | 1,245,488 | 10,968 | 30,053 | 1,286,509 |

In 1916, Nova Scotia produced 492,500 tons or 38.4 per cent of the total; Quebec, 72,250 tons, or 5.6 per cent of the total; and Ontario, 716,000 tons, or 56.0 per cent of the total.

**Rails and fastenings.**—The following table gives the returns of imports and production, the capacity of Canadian mills, and the proportion of Canadian production to consumption.

**Rails and Fastenings Produced and Used in Canada in Gross Tons.**

| | Production Rails. | Production Fastenings. | Imports Rails and Fastenings. | T'l Used and Exported. | Production % of Used. | Production Rails % of Cap. |
|---|---|---|---|---|---|---|
| 1911 | 360,547 | (Est.) 37,000 | 86,750 | 484,297 | 82 | 68 |
| 1912 | 423,885 | 52,157 | 139,800 | 615,842 | 77.2 | 80 |
| 1913 | 506,709 | 54,839 | 163,000 | 724,548 | 77.5 | 95.5 |
| 1914 | 382,344 | 34,165 | 37,600 | 454,109 | 91.5 | 72.2 |
| 1915 | 209,752 | 9,406 | 10,850 | 230,008 | 95.2 | 41.3 |
| 1916 | 81,497 | 6,479 | 12,500 | 100,476 | 87.7 | 13.5 |

Total annual capacity: Rails 530,000 tons; in 1917, 650,000 tons.

It will be seen in comparison with pig iron and other steel products, that Canadian rail mills up to 1914 have been able to operate at a comparatively high rate of production. The principal factors responsible for this condition have been the rapid expansion of Canadian railroads; a comparatively high duty, namely, $7.00 per net ton; and the favorable shipping facilities of the mills by land and water with regard to the points of destination. The tonnage of steel rails exported is not reported nor known accurately; but on several occasions, Canadian rails in quantity have been marketed in the United States at a figure below the American price, in some cases in spite of an import duty, but in recent years, with free entry. Exports in 1915 were about 58,500 G.T. Inasmuch as the price of rails in the United States has been maintained at a fixed level of $28.00 per G.T. for a number of years, it is not surprising that Canadian mills, with the advantage of $7.85 per G.T. duty, have been able to sell the greater part of their production at home; and even in recent years, since the American import

**Don't forget to fill out and return the Pink Slip — See page 32.**

duty has been removed, to market a considerable tonnage of rails in the United States.

**Iron and Steel Bars.**—Under this heading are included a large variety of smaller rolled products ranging in size from 20″ down to 8″, such as narrow plates, nail plate, tack plate, washer plate, and merchant bars up to 12″ in width and 2″ in thickness, and all sizes of bars up to about 6″ in diameter. This classification also includes small structural shapes rolled on merchant mills such as angles up to 4″ and small channels and beams up to 6″. The latter are produced by one mill, only, namely that of the Algoma Steel Corporation.

The figures for production, imports, and consumption are as follows:—

**Production of Merchant Mill Products.**

(Total Annual Capacity 608,000 lb.)

| | Production. | Imports. | Total Used. | Production % of Used. | Production % of Cap. |
|---|---|---|---|---|---|
| 1911 | 344,760 | ...... | ....... | .... | 59.5 |
| 1912 | 373,257 | 208,000 | 578,257 | 64.6 | 64.4 |
| 1913 | 392,340 | 201,500 | 593,840 | 66.2 | 65.3 |
| 1914 | 218,125 | 65,100 | 283,225 | 77.1 | 36.4 |
| 1915 | 328,737 | 101,500 | 430,237 | 76.4 | 54 |
| 1916 | 707,823* | 114,400 | 819,223 | 86.4 | .... |

* The production includes all shell steel rounds rolled on rail mills and merchant mills.

The imports shown above include only the following items from the Customs Reports: bar iron or steel, rolled, etc., exclusive of wire rods of all kinds, shafting, and rolled material of greater value than 3½c per lb. Rolled iron and steel, hoop, scroll, or strip 13 guage and thicker, which is exclusive of hoop iron 12 and 13 guage and thinner, etc. There is also included in the tonnage of imports, rolled iron and steel angles, beams, channels, and other shapes not further manufactured than rolled 35 lb. per lineal yard and less.

The situation of the rolling mills in Canada is particularly disadvantageous. In all about sixteen concerns operating rolling mills. In 1913 there were twenty works in operation, namely: four in Nova Scotia, one in New Brunswick, four in Quebec, nine in Ontario one in Manitoba, and one in Alberta. Seventeen of these mills 20″, 28″, and 16″.

These mills (seventeen 20″, 18″, and 16″ mills, and twenty-three 14″, 12″, 10″, 9″ and 8″ mills) are capable of rolling all the ordinary sizes and shapes of merchant, agricultural, and small structural bars, but are not equipped, as far as is known, to roll the following products: Bands under ½″ and 16 Ge. including all kinds of hoop, scroll, and strip steel, planished and otherwise special in finish; beams and channels under 6″, except one mill owned by the Algoma Steel Corporation; tees, and small special shapes under 6″; corrugated, ribbed, and other patented reinforcing bars; miscellaneous sections such as special agricultural beams and plates, nut, tire, tractor and rim sections, U bars, and other special deformed and miscellaneous shapes.

The greater part of these special shapes are rolled in the United States on what are called "Specialty Mills" especially designed and equipped for producing large tonnages, their costs being accordingly much lower than in the case of mills equipped for producing a greater variety of sections. Hence United States operators have made special efforts to obtain all the tonnage offered both in Canada and the United States in order that these mills might be operated at the highest rate of production possible. There is no doubt that Canadian consumers have been able to obtain the best products and deliveries from these mills, and Canadian mills have therefore been forced to accept the balance of the tonnage obtainable—mainly standard sections and sizes costing more to produce as more frequent changes are necessary—this business having been divided up among many concerns. The widely distributed markets of Canada, involving long hauls form the principal manufacturing centres to the points of consumption, have encouraged the establishment at various points of many small rolling mill plants, whose maximum annual capacity does not as a rule exceed 25,000 tons. These mills have depended for their existence on securing, and have made every effort to secure, the greater part of the local trade in standard shapes and qualities. The competition of these small plants has severely cut into the business of the larger plants which are equipped with full complements of standard merchant mills and with steel plants for furnishing their own requirements of steel. The result of this competition has been the reduction of prices to a minimum, but without any compensating increase in the variety of products.

**Hoops and Bands.**—The returns in respect of imports of rolled bands, hoops, and strip steel 14 guage and thinner are as follows:

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 18,006 |
| 1914 | 14,662 |
| 1915 | 10,242 |
| 1916 | 13,712 |
| 1917 | 16,813 |

Steel hoops are used chiefly in the manufacture of barrels, buckets, boxes, etc., and range in size from ⅜″ to 3″ wide, and 1-40″ to 1-10″ thick. Light bands are used for wooden tanks, vehicles, cars, etc., the size ranging from ⅜″ to 6″ wide and from ⅛″ to 3-16″ thick. These are rolled from small billets usually on a 10″ or 8″ semi-continuous or continuous mill. The variety of light hoops and bands used in Canada would cover practically a full range of these sizes, to roll which would require at least four mills ranging from 14″ to 8″, with an annual capacity of about 150,000 tons. This is the usual number and size of mills installed in plants in the United States where hoops and bands are rolled, and it would be out of the question to install and operate mills of this kind in Canada for the small tonnage required.

**Structural Shapes.**—There are no records of Canadian production of light structural shapes of 6″ and under, rolled on bar mills; although at least four mills ranging in size from 10″ to 18″ roll angles 4″ and under, small channels, beams for agricultural implements and vehicles. These mills also roll angle bars and tie plates, of which the production has been given under the heading of rails; but so far as is known, the Algoma Steel Corporation and Nova Scotia Steel & Coal Company are the only concerns that roll shapes such as small channels, beams, etc., and the variety and tonnage of their output is not known.

Imports of these light structural shapes has amounted to a large tonnage in the past few years, being as follows:—

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 89,459 |
| 1914 | 97,582 |
| 1915 | 27,122 |
| 1916 | 39,455 |
| 1917 | 45,908 |

**Don't forget to fill out and return the Pink Slip — See page 32.**

In the United States practically all such light structural shapes are rolled on bar mills or light structural mills, especially designed for rolling these sections as well as angle bars, tie plates, rail joints and other special sections.

In recent years imports of heavy structural shapes into Canada have been:

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 200,678 |
| 1914 | 212,772 |
| 1915 | 64,981 |
| 1916 | 66,571 |
| 1917 | 74,260 |

In these figures is included a considerable tonnage of heavy shapes weighing over 35 lb. per lineal yard such as I-beams over 20" and channels over 15" which require a special heavy structural mill to roll, so that there would hardly remain enough tonnage of other shapes of this class for a structural mill to roll; such a mill having an annual capacity of at least 300,000 tons. A light structural mill which would roll angles up to 5" or 6" and light beams and channels under 8", also angle bars, tie plates, and heavy implement shapes, would have an annual capacity of about 180,000 tons. Moreover, a large range of sizes and shapes which would have to be rolled on these mills in order to supply all the requirements of the country, would be beyond the capacity of any standard structural mill.

There is no doubt that the past two years have witnessed a very severe depression in steel construction in Canada, and the prospects are good for a considerable increase in structural shapes which will be used in this country. At the present time, the duty on light structural shapes is the same as on rolled bars namely, $7.00, but on heavy shapes it is $3.00 per N.T. The question of whether the latter duty would afford sufficient protection to any Canadian concern willing to risk the heavy cost of installation of structural mills, will be dealt with later on under the heading of "Cost of Production."

**Plates.**—There is one plate mill in Canada. This is operated by the Nova Scotia Steel & Coal Co.; but this being a 20" mill, is only capable of rolling light plates up to about 30" in width. The large tonnage of plates used in Canada under ½" in thickness would probably range from 30" up to 120", used chiefly for bridge construction, car, tank, engine and boiler work. These are imported into Canada under three classifications detailed below.

**Universal Plates.**—These are imported by manufacturers of bridges, structural work and cars. The returns of imports under this item are:

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 52,646 |
| 1914 | 57,763 |
| 1915 | 22,219 |
| 1916 | 25,035 |
| 1917 | 21,504 |

The next range of sizes is entered for import under the description of "Plates not less than 30" x ⅛". The imports of this class have been:

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 56,411 |
| 1914 | 54,832 |
| 1915 | 22,231 |
| 1916 | 27,356 |
| 1917 | 23,884 |

Both of these classes are subject to an import duty of $3.00 per ton under the general tariff.

Another class is entered as "boiler plates not less than 30" x ¼" for use exclusively in the manufacture of boilers." These are entered free, and the annual imports have been:

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 21,535 |
| 1914 | 20,592 |
| 1915 | 5,233 |
| 1916 | 5,858 |
| 1917 | 8,039 |

In addition to the foregoing, there are other plates entered as "rolled iron or steel sheets or plates, sheared or unsheared, and skelp sheared or rolled in grooves." These are sheets or plates thicker than 14 guage of a class made in Canada and are subject to a duty of $7.00 under general tariff. The imports of this class have been:

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 42,120 |
| 1914 | 40,384 |
| 1915 | 14,335 |
| 1916 | 17,245 |
| 1917 | 23,591 |

The imports in tons of these four classes of plates have been:

| Year Ending March. | Imports—N.T. |
|---|---|
| 1913 | 172,712 |
| 1914 | 173,571 |
| 1915 | 64,018 |
| 1916 | 75,494 |
| 1917 | 77,018 |

The first class of plates mentioned above, which are known as "universal plates," range in size from 12" up to about 48" in width, and are rolled on a universal plate mill, which, in addition to its horizontal rolls, which reduce the material in thickness, has vertical rolls on either side, which regulate the width of the plate. These vertical rolls are adjustable to any width up to the size of the mill. The edges of the plates are regular and straight and do not need to be sheared.

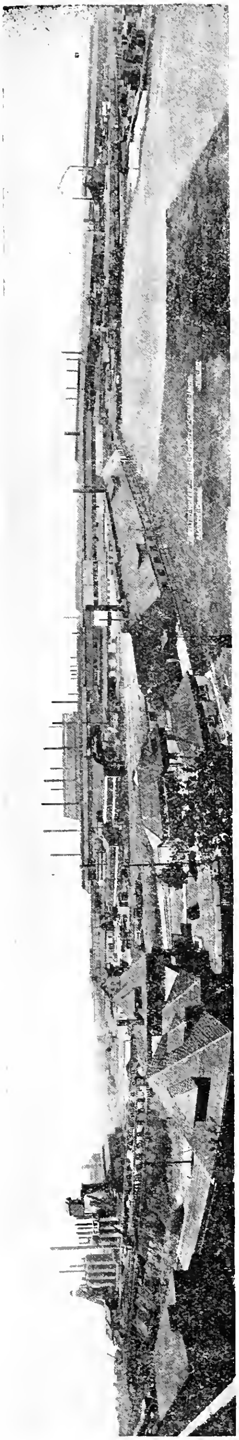
The second class of plates described as "not less than 30" wide x ¼" thick" and boiler plates of the same dimensions, are usually the product of a sheared plate mill, in which the steel is reduced to the desired thickness, but the edges are not rolled or regular. These plates must be sheared when cold to the desired width and length or into special shapes as ordered.

The fourth class of plates mentioned above are usually rolled on a universal plate mill and vary in width from 12" up to 40".

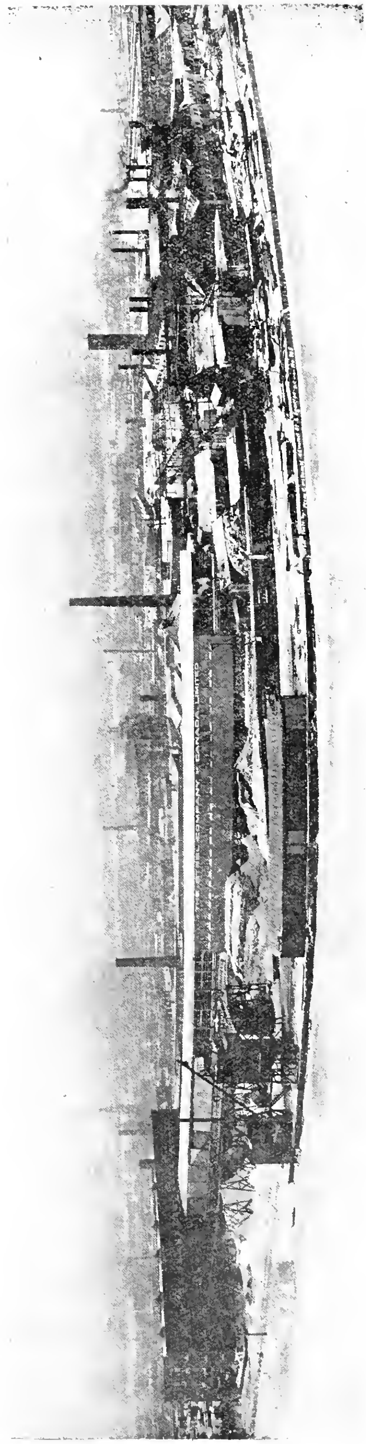
Skelp is also rolled on this kind of mill and is imported as raw material for the manufacture of punched and sheared hardware, metal parts, etc., such as hinges, washers, and other similar articles.

It is apparent that the maximum consumption of universal plates in Canada has not exceeded 90,000 to 95,000 tons annually, and of sheared plates not over 75,000 to 78,000 tons, these quantities covering a very large range of widths and sizes.

A universal plate mill rolling universal plates up to 48" wide and sheared plates up to 72" wide would have an annual capacity of about 150,000 tons. This would cover the greater proportion of all sizes imported, with the exception of especially wide ones, which would have to be rolled on an extra large sheared



The Works of The Steel Company of Canada, Limited, at Hamilton, Ont.



The Works of The Steel Company of Canada, Limited, at Montreal, Que.

**Don't forget to fill out and return the Pink Slip — See page 32.**

plate mill. The smaller universal plates under 30" could be rolled on a small universal mill together with skelp. The annual output of such a mill would be about 100,000 tons.

There would appear to be a favorable opportunity for the installation of two such mills in Canada, as the prospects of an increase in the total consumption of plates of various sizes appear assured. The question of adequate protection would, however, have to be considered. It would be more favorable to the manufacturer of plates in Canada to establish a uniform duty on plates of all kinds.

**Sheets.**—Sheets of any kind are not made at present in Canada, although a plant was built at one time for the purpose of manufacturing them. The attempt was not successful, but the plant has recently been purchased and removed to Hamilton by the Steel Company of Canada, Limited, which will commence manufacturing sheets of 14 guage and thinner about the beginning of 1918.

The comparative statistics of imports of various classes of sheets are as follows:

**''Rolled Iron or Steel Sheets, Polished or Not, 14 Gauge and Thinner''**

| | Imports—N.T. | |
|---|---|---|
| Year Ending March. | Dutiable. | Free. |
| 1913.................... | 66,063 | 7,377 |
| 1914.................... | 39,125 | 15,954 |
| 1915.................... | 29,054 | 7,260 |
| 1916.................... | 46,512 | 1,333 |
| 1917.................... | 50,784 | 2,258 |

**''Canada Plates, Russia Iron, Terne Plates and Rolled Sheets of Iron or Steel Coated with Zinc, Spelter or Other Metal, of all Widths and Thickness, N.O.P.''**

| | Imports—N.T. | |
|---|---|---|
| Year Ending March. | Dutiable. | Free. |
| 1913.................... | 11,974 | 7,069 |
| 1914.................... | 8,176 | 10,192 |
| 1915.................... | 8,791 | 5,733 |
| 1916.................... | 10,134 | 2,078 |
| 1917.................... | 12,279 | 525 |

**''Galvanized Sheets, Flat and Corrugated.''**

| | Imports—N.T. | |
|---|---|---|
| Year Ending March. | Dutiable. | Free. |
| 1913.................... | 28,111 | 28,095 |
| 1914.................... | 16,996 | 33,758 |
| 1915.................... | 15,130 | 20,185 |
| 1916.................... | 17,441 | 6,542 |
| 1917.................... | 10,529 | 455 |

There are a few other classifications of imported sheets which do not amount to any significant tonnage and will be omitted from the total tonnage. All of the above sheets are subject to a 5 per cent duty when imported from the United States and are free from the United Kingdom. Import returns are as follows:

| | Total Imports—N.T. | |
|---|---|---|
| Year Ending March. | Dutiable. | Free. |
| 1913.................... | 106,148 | 42,541 |
| 1914.................... | 64,291 | 69,904 |
| 1915.................... | 52,971 | 33,178 |
| 1916.................... | 74,087 | 9,953 |
| 1917.................... | 73,592 | 3,238 |

In view of the fact that after the war Imperial tariff walls may be raised by increasing the duties on all products imported from all foreign countries outside of the Empire and the Allied Nations, it is possible that a fair protective duty on sheets may be imposed under the general tariff with a moderate preferential duty.

There is no apparent reason why the whole of the tonnage of sheets now being imported from the United States and England should not be made in Canada. Sheet mills do not cost as much to build and equip as most modern rolling mills such as are required for bars, plates and structural shapes. The process of rolling sheets differs from the process of rolling these other products, as the rolls, instead of having specially designed grooves which form the shape of product, are perfectly smooth. Black sheets are rolled from sheet bars about 8" wide and from ½" to 1" thick cut in lengths of 30'. These are rolled on a continuous mill from a large billet. After the sheets have had a number of passes between the rolls,, they are reduced to a certain thickness after which they are doubled so that two or more thicknesses pass between the rolls at the same time. This doubling is repeated and the sheets come out in a pack so closely united by pressure of the rolls, that it is necessary to pull them apart in separating individual sheets. In reducing the sheets by various passes, they are carried by hand from one stand of rolls to the next. The furnaces for heating the sheet bars and annealing the finished sheets are simple in design and operation. There is no complicated machinery for the handling of the product and the principal item of cost is that of labor. Sheet mills can be established in units of various sizes and capacity according to the tonnage of each size which will be produced.

The tonnage imported would, however, include a wide range of sizes, qualities, and finishes which would require different styles of mills to produce economically. It would therefore appear that if an import duty were imposed for the protection of the Canadian manufacturer that an ad valorem duty would be fairer and more advantageous than a specific duty, having regard in particular to the fact that labor costs enter so largely into the cost of manufacture.

Sheets are mainly used for building construction, not only for the walls and roofs of sheet metal buildings, but also in many various small and fabricated forms. Annealed sheets enter into the manufacture of a great variety of Canadian products such as stoves, stamped and drawn work, and utensils and vessels of various kinds. They are also used in large quantities for electrical purposes.

In addition to the black and galvanized sheets used in manufacturing and construction work, there is also a large tonnage of tin plate imported into this country for the manufacture of cans, containers, and other small parts punched from tin plate.

Tin plate is made from black sheets, of a better finish and having a smoother surface suitable for tining. The additional processes are pickling, annealing and cold rolling. The first process removes impurities from the surface; annealing makes the material pliable; and cold rolling insures perfect smoothness and correctness in gauge. The tin is then applied by drawing the plates between rolls immersed in molten tin, thereby giving a smooth bright coating to the black plates. Roofing plates, as distinguished from galvanized sheets, are usually coated with a mixture of lead and tin and are called terne plates.

The imports of tin plate are shown above under the heading of ''Canada plates and rolled sheets coated with zinc, spelter, or other metals.'' The greater part of tin plate used in Canada was formerly imported from Great Britain, but of recent years, the United States has become the largest exporter to Canada.

**Don't forget to fill out and return the Pink Slip — See page 32.**

**Pipe, Tubing, and Fittings.**—The greater part of the wrought iron and steel pipe used in Canada under 10″ in diameter is made by three concerns, namely: Canadian Tube & Iron Company, Montreal; Page-Hersey Iron Tube & Lead Company, Toronto; Steel Company of Canada, Limited, Hamilton. The first and last mentioned make only butt-weld pipe 4″ and under in diameter, while the Page-Hersey Company make also lap-weld pipe from about 4″ to 10″ in diameter.

The total production of wrought pipe in Canada has not been reported, but may be estimated fairly closely from the tonnage of skelp imported by these manufacturers. The imports in recent years of wrought pipe not over 4″ in diameter, have been as follows:

| Year Ending March. | Imports—Value. |
|---|---|
| 1913 | $486,067 |
| 1914 | 375,012 |
| 1915 | 144,309 |
| 1916 | 117,588 |
| 1917 | 368,521 |

**Skelp.**

| Year Ending March. | Imports—N.T. Dutiable General. | Free—Not over 4¾″ |
|---|---|---|
| 1913 | 112,996 | 1,033 |
| 1914 | 101,036 | 560 |
| 1915 | 94,317 | 372 |
| 1916 | 95,240 | ..... |
| 1917 | 66,244 | 1,684 |

Practically all this skelp is made from bessemer steel and is imported from the United States. It is all rolled on special skelp mills consisting of about ten stands of continuous rolls like a continuous sheet bar of billet mill. For the heavier grades of skelp the slabs or sheet bars from which it is rolled are first broken down in a small universal mill. The larger sizes of skelp are rolled entirely on small universal mills. The annual capacity of such mills would run from 75,000 to 175,000 tons. No doubt one mill would be able to furnish the greater part of the sizes used in Canada, namely, for pipe from 2″ to 10″ in diameter. Sizes of skelp for pipe smaller than 2″ can be rolled on bar mills, but there is none of the continuous type, rolling small flats, bands, or skelp, in Canada.

The greater tonnage of tubing which is imported into Canada at present is large lap-weld over 4″, of which a great quantity is used for gas, oil, and mining purposes.

The total value of imported wrought pipe over 4″ has been:

| Year Ending March. | Imports—Value. Total. | Over 4″ up to 10″ | Over 10″ |
|---|---|---|---|
| 1913 | $1,586,452 | ....... | ....... |
| 1914 | 698,186 | ....... | ....... |
| 1915 | 384,122 | 190,201 | 193,921 |
| 1916 | 238,288 | 85,882 | 152,406 |
| 1917 | 373,803 | 312,297 | 61,506 |

Since 1915 separate returns have been made for pipe over 10″ in diameter.

The duty on the former class is 30 per cent general tariff and on the latter 15 per cent general tariff, due to the lower cost of production per ton of large sizes of pipe. The imports of this class of material have decreased so rapidly that there is little room for doubt that Canadian mills will gradually furnish the whole of the tonnage needed in Canada, where there are not as many grades and thicknesses required as in the United States.

The above classes cover what is known as standard, extra heavy, double extra heavy, oil country, line and drive pipe used extensively in mining and development work in the United States.

**Boiler Tubes.**—These are not manufactured at all in Canada, but have been imported in considerable quantities from England, Germany, and the United States. They are made from extra refined iron and very soft steel, and are generally lap-welded, although a considerable portion are seamless. They are imported free of duty.

The value of imports for the last four years has been:

| Year Ending March. | Imports—Value. |
|---|---|
| 1913 | $903,016 |
| 1914 | 886,699 |
| 1915 | 356,992 |
| 1916 | 364,143 |
| 1917 | 1,119,222 |

The class of pipe, second in point of quantity imported into Canada is: "Iron or steel tubing plain, galvanized, riveted, corrugated or otherwise specially manufactured."

The value of the imports of this class of pipe for the last four years has been:

| Year Ending March. | Imports—Value. |
|---|---|
| 1913 | $1,014,005 |
| 1914 | 1,325,069 |
| 1915 | 395,026 |
| 1916 | 287,716 |
| 1917 | 228,094 |

In this class is included all kinds of fabricated pipe such as culvert, drain, locked joint, spiral, riveted, chimney pipe, etc. The rate of duty is 30 per cent under the general and 20 per cent under the preferential tariff, the greatest proportion being imported from the United States. Pipe of this class is never made by steel plants or rolling mills but is the product of smaller manufacturers making a wide variety of fabricated goods from sheet steel and plates. This also applies to "iron tubing brass covered, imported by manufacturers of iron and brass bedsteads," of which the imports also represent a considerable sum annually. The establishment of skelp mills by one or other of the steel plants in Canada will no doubt lead to the installation of a number of tube mills, producing a greater variety of pipes and tubes than are now made. The duty of 30 per cent and 35 per cent, on pipe up to 10″ is a fair measure of protection to encourage the establishment of mills equipped to make the other classes of pipe, including boiler tubes required in Canada.

Fittings of iron and steel for pipe of all descriptions are imported in enormous quantities. The value of the imports in the last four years has been:

| Year Ending March. | Imports—Value. |
|---|---|
| 1913 | $1,266,171 |
| 1914 | 1,020,564 |
| 1915 | 729,472 |
| 1916 | 452,345 |
| 1917 | 718,694 |

An immense variety of fittings for all classes of pipe are included under this heading, namely, cast iron of all sizes up to 36″, small wrought iron, steel and malleable fittings, and small pipe up to 6″, also all the miscellaneous joints and fittings required for fabricated pipe. A very large proportion of these fittings would comprise valves of every description, of which there is an immense variety imported into Canada. This

**Don't forget to fill out and return the Pink Slip — See page 32.**

branch of business is suited to manufacturers especially equipped and not for steel makers.

**Wire Rods.**—These are made in Canada by two concerns, namely, The Dominion Iron & Steel Company, and The Steel Company of Canada, Limited.

The mill of the former company was installed in 1904; that of the latter in 1912. The Dominion Company, in the year 1913, built wire and nail departments in order to utilize their surplus of wire rods. The Nova Scotia Company now furnishes a large tonnage of wire rods to the manufacturers of wire for sale or for making wire nails.

The production and consumption of wire rods for the past four years is given in the following table:

**Production of Wire Rods—G.T.**

| | Production. | Imports. | Total Used (Incl. Exp.) | Production % of Used. | Production % of Cap. |
|---|---|---|---|---|---|
| 1911 | 76,617 | ...... | ....... | .... | 85.2 |
| 1912 | 64,082 | 83,850 | 147,932 | 43.3 | 71.2 |
| 1913 | 68,048 | 62,800 | 130,848 | 52 | 46.5 |
| 1914 | 59,050 | 58,900 | 117,950 | 50 | 32.8 |
| 1915 | 114,829 | 61,900 | 176,729 | 65.1 | 63.9 |
| 1916 | 174,490 | 52,280 | 226,770 | 77.0 | 97.0 |

It will be observed that in the year 1913, when the second mill was established at Hamilton, the total production of the Dominion did not increase to any great extent, and in 1914, was actually less than during any of the preceding three years. However, the tonnage of wire rods imported was decreased considerably, and, during the year 1915, 65 per cent of the total consumption of the country was produced in Canada, while the percentage of capacity at which Canadian mills were able to operate increased considerably over that of either of the preceding two years.

Of the wire rods imported from the United States, a considerable quantity was used by manufacturers of chain, but a large proportion was also imported by manufacturers of wire and wire nails for use in their own factories, on account of the extremely low prices at which wire rods were obtainable during the past few years. A considerable tonnage was also imported for the manufacture of wire products, which were afterwards exported, especially since the year 1914.

The export trade of wire and wire products has developed enormously since that time especially between Canada and the United Kingdom and other British possessions. The duty of $3.50 per net ton on wire rods was granted from July 1st, 1914, and has already proved a material benefit to the rod makers, without apparently affecting the manufacturers of wire and wire nails. At the present time practically all the wire nails used are made in Canada, a condition which has existed for some time owing to the duty of 60c per keg. The following table shows the production and imports of wire nails for the past four years:

**Production of Wire Nails in Canada.**

| | Production Kegs 100 lb. | Imports Cut Nails. | Imports Wire Nails. | Total Used and Exported. | Production % of Cap. (1915 capacity 2,000,000) |
|---|---|---|---|---|---|
| 1912 | 1,490,000 | 13,594 | 47,813 | 1,551,407 | 77 |
| 1913 | 1,520,000 | 3,867 | 31,141 | 1,555,008 | 78 |
| 1914 | 1,144,000 | 4,689 | 19,379 | 1,168,068 | 58 |
| 1915 | 1,636,000 | 315 | 10,617 | 1,646,932 | 82 |
| 1916 | 1,757,000 | 4,600 | 86,872 | 1,848,472 | 92 |

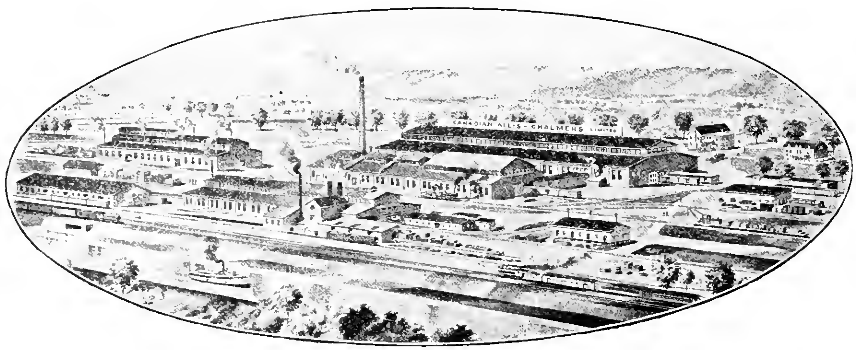
In addition to wire rods imported by manufacturers of wire for conversion in their own factories, a tonnage of wire almost as large has also been imported direct by consumers as is shown in the following table giving the imports of the more important classes for the past four years.

**Imports of Wire.**

| 12 Months to March. | 1913. | 1914. | 1915. | 1916. | 1917. |
|---|---|---|---|---|---|
| Free— | | | | | |
| Bessemer and 'Homo spring wire......... | 1,014 | 925 | 576 | 980 | 1,631 |
| Barbed wire.......... | 22,306 | 11,764 | 16,270 | 19,467 | 22,621 |
| 9-12-13 Ge. galv. wire. | 41,169 | 35,960 | 37,912 | 35,297 | 18,843 |
| Total free.......... | 64,489 | 48,649 | 54,758 | 55,744 | 43,095 |
| Dutiable— | | | | | |
| Wire of all kinds, n.o.p. (20%) ............ | 5,909 | 5,228 | 3,435 | 2,978 | 4,111 |
| Woven wire cloth and netting (30%)....... | 1,770 | 2,498 | 2,118 | 2,000 (Est.) | 1,170 (Est.) |
| Wire fencing between 9 and 14 Ge. (15%).. | 827 | 699 | 911 | 1,000 | 312 |
| Total dutiable....... | 8,506 | 8,425 | 6,464 | 5,978 (Est.) | 5,893 (Est.) |
| Total dutiable and free —N.T. ............ | 72,995 | 57,074 | 61,222 | 61,722 | 48,988 |

It will be noted that the bulk of this tonnage enters free in the shape of wire, for fencing and for the manufacture of mattresses, the latter being of class not formerly made in Canada, but which now is being made in considerable quantities.

The tonnage of free wire imported forms 85 per cent to 90 per cent of the total imports. If the total imports of wire are added to the total consumption of




Works of Canadian Allis-Chalmers, Limited, at Montreal, Que.

**Don't forget to fill out and return the Pink Slip — See page 32.**

wire rods as given in a previous table, it will afford an idea of the approximate total tonnage of wire products of all kinds consumed in Canada. The figures are:

| | Total Rods used plus Nails and Wire imported—N.T. | % made from Can. Rods. |
|---|---|---|
| 1912 | 286,600 | 22.4 |
| 1913 | 229,900 | 29.6 |
| 1914 | 212,600 | 27.8 |
| 1915 (Est.) | 270,300 | 41.5 |
| 1916 (Est.) | 390,900 | 44.7 |

It is evident from a consideration of the figures presented in the foregoing table, so far as the bulk of the products manufactured by the primary or basic iron and steel industries of Canada are concerned, that their present equipment and capacity is a great deal more than sufficient to supply the total Canadian demand for these products in Canada; and that important and valuable opportunities are presented Canadian manufacturers to supply a considerable proportion of the products which are now imported wholly from foreign countries, provided that they can obtain the necessary protection and support to engage in this business with a reasonable assurance of profit.

**Comparison of Cost of Production of Iron and Steel in Canada and the United States.**

The bulk of the export trade of the United States in iron and steel products has been developed from the beginning and is now being carried on extensively and principally by the United States Steel Corporation, the greatest undertaking of the kind in point of size, resources and variety of products in the world, and other large concerns located in the Buffalo, Cleveland, Youngstown, Pittsburgh and Chicago districts.

The United States Steel Corporation, as is well known, owns vast ore deposits in the Lake Superior region with which its plants in these districts are supplied. It also owns and operates the mining railroads which transport the ore to the upper lake ports, the boat lines which carry ore to the lower lake ports and the railroads which take the ore from the vessel to the blast furnaces. All the other principal independent companies, practically own and control their supply of ore as well as vessels transporting it on the Great Lakes. Those iron and steel industries that are not so fortunately situated in this respect are forced to buy their ore in the open market, where a very large proportion of the total ore consumed is sold each year by mining companies that do not own blast furnaces or are not financially associated with blast furnace interests. The market price of ore is fixed each fall for the succeeding year, and the prices of various grades sold by different mines are based on four standard grades, namely, Old Range, Bessemer and Non-Bessemer; and Mesabi, Bessemer and Non-Bessemer. The metallic contents of these ores is taken as a standard and the price of all other ores is adjusted according to their variation from this standard in metallic contents, phosphorus and moisture.

The published prices for the last seven years of these four grades, which are based on delivery at Lake Erie docks, have been as follows:

| | Old Range | | Mesabi | | Frt. Rate G.T. to Lake Erie |
|---|---|---|---|---|---|
| | Bess. | Non-Bess. | Bess. | Non-Bess. | Ports. |
| 1910 | $5.20 | $4.20 | $4.75 | $4.00 | $0.55 |
| 1911 | 4.50 | 3.70 | 4.25 | 3.50 | .50 |
| 1912 | 3.75 | 3.00 | 3.50 | 2.85 | .40 |
| 1913 | 4.40 | 3.60 | 4.15 | 3.40 | .45 |
| 1914 | 3.75 | 3.00 | 3.50 | 2.85 | .40 |
| 1915 | 3.75 | 3.00 | 3.45 | 2.80 | .40 |
| 1916 | 4.45 | 3.70 | 4.20 | 3.55 | .50 |

The standard iron content for Bessemer ores is 55 per cent; for Non-Bessemer, 51.50 per cent.

As all the figures in this paper relative to production, imports, and manufacturing capacities of plants are for the years 1911-1915 inclusive, the average of the ore prices for these years may be taken as representing the normal price during that period. This average is $3.08 per G.T. unloaded on Lake Erie dock for Mesabi iron ores.

The comparative costs of making pig iron and steel in the various processes of manufacture from pig iron to the finished product, may now be considered, and in this connection the estimated cost of mining and transporting Mesabi ore to Lake Erie ports in the years 1910 and 1915, respectively, is given in the following table:

| | 1910. | 1915. |
|---|---|---|
| Cost of ore at mine, including labor, expense, depreciation and royalty | $1.23 | $1.23 |
| Railway freight | .41 | .40 |
| Lake freight | .62 | .40 |
| Total cost lower lake ports | $2.26 | $2.03 |
| Quoted market price | 4.00 | 2.80 |
| Profit | 1.74 | .77 |

The freight rates for the year 1910 as shown represent the net transportation costs of the United States Corporation, using its own railroads and lake vessels, whereas in 1915, the lake freight charge of 40c is the open market contract price. Taking the average of these two costs at lower lake ports as $2.15 and comparing it with average market price of $3.08 for the 5-year period, the average price paid in the open market by companies not controlling their own ore mines has been 93c above that of the Steel Corporation and other large United States companies. In addition to this difference, it should be pointed out that the average freight rates given above would include a profit of not less than 15c a ton on ore to companies owning their own mines, railroads, and lake vessels. It seems fair, therefore, to assume that small concerns which buy their ore in the market—and in this category is included all the Ontario iron and steel undertakings using ores imported from the United States—have to pay over $1.00 per ton on ore more than the large American companies. Assuming that an average of two tons of ore is required to make one ton of pig iron, the difference in increased cost of pig iron for ore alone is therefore at least $2.00.

Most of the large concerns in the United States also own coal mines from which is obtained all the coal required by them for coking, miscellaneous heating, and steam purposes. These coal lands are situated in Ohio and Pennsylvania where, in the Connellsville region mainly, the better grade of coal is found. These fields are in easy reach of Pittsburgh, and the cost of transportation on coal is therefore very small. The greater part of the coal is brought to the coke ovens at the blast furnaces for coking. Coal used in the Chicago district is brought partly from Pennsylvania and partly from Illinois and Indiana. This coal is high in ash and volatile matter, and must be mixed with the better grade of coal from the Connellsville and Pocohontas region. It has been found that the average selling price of coke for the 5-year period, 1910-1915, was about $2.00 per N.T. at ovens, and the average cost to the U.S. Steel Corporation was about $1.60. For the purpose of estimating the present cost of pig iron, a profit of 25c per ton has been assumed.

The total profit on ore and coke per ton of iron would therefore be $2.40. It is apparent, therefore, that the cost of transportation of ore and coal or coke, is a very large factor in the cost of production of pig iron, and the total cost of assembling raw materials is the deciding feature affecting the economic location of blast furnaces.

The freight rates on ore and coal from Lake Superior mines to blast furnaces at three Ontario points and in the three principal American districts are tabulated hereunder. The three Canadian plants located in Ontario are selected for reference because they are principally concerned in the competition originating from the United States, especially on account of drawing their supply of ore and coal from the same districts as the American furnaces.

**Freight Rates and Total Assembling Cost on Ore and Coke.**

| | Freight on Ore G.T. Lake, Rail and Handling per ton Iron. | | | Freight on Coke (N.T.) Rail and Boat per ton Iron. | | Total Cost per ton Iron. | |
|---|---|---|---|---|---|---|---|
| | | | | Basic. | Fdry. | Basic. | Fdry. |
| Sault Ste. Marie.. | $0.30 | $0.10 | $0.80 | $2.20 | $2.64 | $3.00 | $3.44 |
| Hamilton ........ | .40 | .65 | 2.10 | 2.40 | 2.88 | 4.50 | 4.98 |
| Port Colborne..... | .40 | .10 | 1.00 | 2.40 | 2.88 | 3.40 | 3.88 |
| Buffalo ......... | .40 | .10 | 1.00 | 1.85 | 2.22 | 2.85 | 3.22 |
| Pittsburgh ....... | .40 | .88 | 2.55 | .75 | .90 | 3.30 | 3.45 |
| Chicago ......... | .40 | .10 | 1.00 | 2.00 | 2.40 | 3.00 | 3.40 |

| | Basic. | Fdry. |
|---|---|---|
| Average cost at Sault Ste. Marie, Hamilton and Port Colborne .......... | $3.63 | $4.10 |
| Average cost at Buffalo, Pittsburgh and Chicago. | 3.05 | 3.36 |

Sault Ste. Marie, Port Colborne, Buffalo, and Chicago are all lake points and the rail haul to the blast furnaces is therefore negligible. A charge of 10c for switching and unloading has been assumed as the approximate cost of handling at these points. The total freight charge on ore per ton of iron is based on the estimated consumption of two tons of ore per ton of iron. The freight on coke, in the case of Sault Ste. Marie, includes the cost of a rail haul to Buffalo and boat to the Sault; while in the case of Chicago, the freight rate is based on an estimate of the proportion of coal brought from Pennsylvania together with that mined in Illinois and Indiana. The freight rate on coke per ton of iron is based on 1.2 tons of coke to one of iron, which equals 2,400 lb. per G.T. of pig iron. This practice is based on the average consumption of coke per ton of iron, in the past four years, reported by the American Iron & Steel Institute.

## Comparison of Cost of Basic and Foundry Pig Iron in the United States and Canada.

| | United States. | | Canada. | | Difference. | |
|---|---|---|---|---|---|---|
| | Basic. | Fdry. | Basic. | Fdry. | Basic. | Fdry. |
| Price per ton ore at lower lake ports. | $3.08 | $3.08 | $3.08 | $3.08 | .... | .... |
| Less lake freight. | .40 | .40 | .40 | .40 | .... | .... |
| Price at upper lake ports...... | $2.68 | $2.68 | $2.68 | $2.68 | .... | .... |
| Price of coke at Connellsville ovens | 2.00 | 2.00 | 2.00 | 2.00 | .... | .... |
| Cost of ore per ton of iron ........ | 5.36 | 5.36 | 5.36 | 5.36 | .... | .... |
| Cost of coke per ton of iron..... | 2.00 | 2.40 | 2.00 | 2.40 | .... | .... |
| Assembling cost of ore and coke.. | 3.05 | 3.36 | 3.63 | 4.10 | $0.58 | $0.74 |
| Cost of ore and coke per ton of iron. | $10.41 | $11.12 | $10.99 | $11.86 | $0.58 | $0.74 |
| **Furnace conversion cost** | | | | | | |
| Limestone ....... | $0.50 | $0.55 | $0.55 | $0.60 | .... | .... |
| Labor .......... | .55 | .55 | .80 | .80 | .... | .... |
| Steam .......... | .35 | .35 | .70 | .70 | .... | .... |
| Surplus gas credited | (.55) | (.55) | (.85) | (.85) | | |
| Repairs and maintenance ........ | .10 | .10 | .15 | .15 | .... | .... |
| Supplies and expense ......... | .35 | .35 | .70 | .70 | .... | .... |
| Relining fund ... | .18 | .18 | .25 | .25 | .... | .... |
| Contingent fund.. | .05 | .05 | .05 | .05 | .... | .... |
| Total conversion | $1.53 | $1.58 | $2.35 | $2.40 | $0.82 | $0.82 |
| Total cost of pig iron .......... | $11.94 | $12.70 | $13.34 | $14.26 | $1.40 | $1.56 |
| Less profit on ore & coke included. | 2.40 | 2.50 | .... | .... | 2.40 | 2.50 |
| | $9.54 | $10.20 | .... | .... | $3.80 | $4.06 |

**Considering difference in assembling cost, total cost would be:**

| | | | | | Credit for coke by-products. | |
|---|---|---|---|---|---|---|
| Sault Ste. Marie.. | .... | .... | $12.51 | $13.36 | $1.40 | .... |
| Hamilton ....... | .... | .... | 14.21 | 15.14 | 1.45 | $1.75 |
| Port Colborne .... | .... | .... | .... | 14.04 | 1.40 | 1.70 |
| Buffalo ......... | $9.34 | $10.06 | .... | .... | 1.35 | 1.65 |
| Pittsburgh ...... | 9.79 | 10.29 | .... | .... | 1.25 | 1.50 |
| Chicago ......... | 9.49 | 10.24 | .... | .... | 1.40 | 1.70 |

Extra for benzol by-products 70c.

| Selling Prices. | | United States. Basic. (Valley) | United States. Foundry. (Buffalo) | Canada. Basic. | Canada. Foundry. |
|---|---|---|---|---|---|
| Average | 1912 | $13.90 | $14.89 | | |
| | 1913 | 14.77 | 14.87 | Average price of all kinds of Pig Iron Imported into Canada 12 months ending March 31st. | |
| | 1914 | 12.80 | 12.84 | | |
| | 1915 | 13.78 | 13.98 | | |
| | 1916 | 19.87 | 20.63 | | |
| Minimum | 1912 | 12.26 | 13.62 | | |
| | 1913 | 12.83 | 13.07 | 1914 | $14.10 |
| | 1914 | 12.50 | 12.08 | 1915 | 15.15 |
| | 1915 | 12.50 | 12.44 | 1916 | 13.80 |
| | 1916 | 17.88 | 18.00 | 1917 | 24.80 |

## Comparative Cost of Open Hearth Ingots—(Per G.T.)

| | United States. | Canada. | Difference. |
|---|---|---|---|
| Cost of basic pig iron per G.T......... | $9.54 | $13.34 | .... |
| Per cent of pig iron used.............. | 55% | 45% | .... |
| Per cent of scrap used at $11.00 per G.T. | 40% | 53% | .... |
| Per cent of ore, cinder and scale used at $5.00 per G.T.................. | 5% | 2% | .... |
| | 100% | 100% | .... |
| **Cost of materials used.** | | | |
| Pig iron ............................ | $5.25 | $5.98 | .... |
| Scrap .............................. | 4.40 | 5.83 | .... |
| Ore, cinder and scale.................. | .25 | .10 | .... |
| | $9.90 | $11.91 | .... |
| Lbs. of steel ingots produced from 100 lb. charge ........................ | 89 lb. | 89 lb. | .... |
| Cost per G.T. ingots................... | $11.10 | $13.40 | $2.30 |
| Reagents (Ferro-alloys, etc.)............ | .35 | .40 | .... |
| Limestone and fluxes.................. | .15 | .20 | .... |
| Fuel ............................... | .65* | 1.60x | .... |
| Labor .............................. | .65 | 1.00 | .... |
| Moulds and stools .................... | .10 | .15 | .... |
| Materials in repairs and maintenance.... | .10 | .15 | .... |
| Supplies and expense.................. | .50 | .85 | .... |
| Rebuilding fund ...................... | .35 | .55 | .... |
| Total conversion .................. | $2.85 | $4.90 | $2.05 |
| Total cost of open hearth ingots per G.T. | $13.95 | $18.30 | $4.35 |

* Natural gas. x Prod. gas.

## Estimated Cost of Structural Shapes—(Over 35" per Lin. Yd.)

| | United States. | Canada. | Difference. |
|---|---|---|---|
| Cost of ingots per G.T................. | $13.95 | $18.30 | $4.35 |
| Lbs. of ingots per 100 lbs. of blooms... | 115 lb. | 115 lb. | .... |
| Lbs. of scrap recovered for 100 lbs. of blooms .......................... | 12 lb. | 12 lb. | .... |

**Cost of Blooms.**

| | | | |
|---|---|---|---|
| Cost of waste | $0.78 | $1.43 | .... |
| Cost of labor | .35 | .50 | .... |
| Cost of fuel | .15 | .50 | .... |
| Expenses | .45 | 1.00 | .... |
| | $1.73 | $3.43 | $1.53 |
| Total cost of blooms | $15.68 | $21.73 | $4.73 |

**Cost of Rolled Shapes.**

| | | | |
|---|---|---|---|
| Lbs. of blooms used for 100 lbs. of shapes | 118 lb. | 118 lb. | .... |
| Lbs. of waste recovered for 100 lbs. of shapes | 15 lb. | 15 lb. | .... |
| Cost of waste | $1.41 | $2.27 | .... |
| Cost of labor | 1.75 | 2.50 | .... |
| Cost of fuel | .20 | .65 | .... |
| Expenses | 1.65 | 2.25 | .... |
| | $4.77 | $7.67 | $2.90 |
| Total cost of structural shapes, per G.T. | $20.45 | $29.40 | $8.95 |
| Total cost of structural shapes per 100.. | .913 | 1.315 | .402 |

**Selling Prices—**

| | (Pittsburgh Base) Average. | Minimum. | Average Price of Imports from United States. | |
|---|---|---|---|---|
| 1912 | $1.30 | $1.11 | Year ending March 1913 | $1.33 |
| 1913 | 1.42 | 1.24 | Year ending March 1914 | 1.41 |
| 1914 | 1.16 | 1.05 | Year ending March 1915 | 1.28 |
| 1915 | 1.30 | 1.10 | Year ending March 1916 | 1.50 |
| 1916 | 2.50 | 1.87 | Year ending March 1917 | 2.76 |

## Estimated Cost of Large Billets (Per G.T.)

| | United States. | Canada. | Difference. |
|---|---|---|---|
| Price of ingots per G.T. | $13.95 | $18.30 | $4.35 |
| Lbs. of ingots used per 100 lbs. of billets | 115 lb. | 115 lb. | .... |
| Lbs. of scrap recovered per 100 lbs. billets | 12 lb. | 12 lb. | .... |
| Cost of waste | $ .78 | $1.43 | .... |
| Cost of labor | .50 | .70 | .... |
| Cost of fuel | .20 | .50 | .... |
| Expenses | .75 | 1.25 | .... |
| | $2.23 | $3.88 | $1.65 |
| Total cost of large billets per G.T. | $16.18 | $22.18 | $6.00 |

## Cost of Small Billets—(Per G T.)

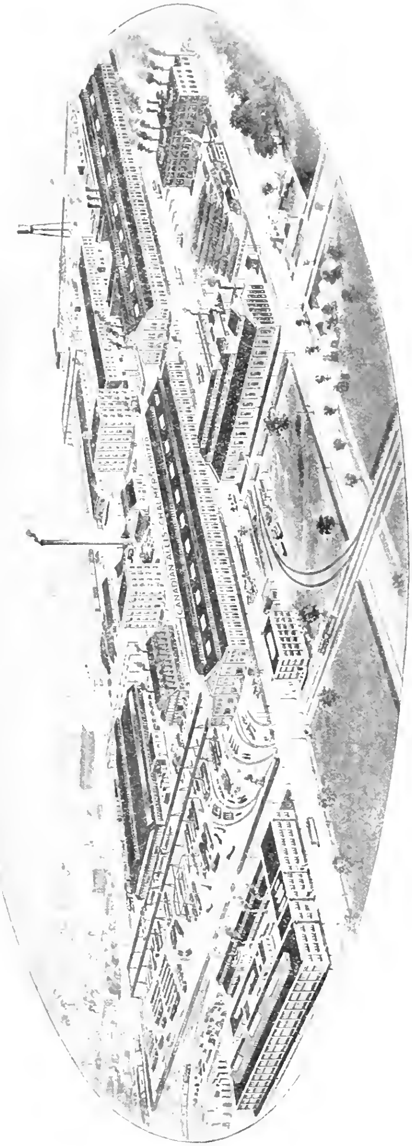
(Re-rolled direct from large billets.)

| | | | |
|---|---|---|---|
| Price of large billets | $16.18 | $22.18 | $8.00 |
| Lbs. of large billets used per 100 lb. of small billets | 103 lb. | 103 lb. | .... |
| Lbs. of scrap recovered per 100 lb. small billets | 3 lb. | 3 lb. | .. |
| Cost of waste | $0.16 | $0.33 | ... |
| Cost of labor | .30 | .55 | .... |
| Cost of fuel | .. | .... | .. |
| Expenses | .40 | .60 | ... |
| | $0.86 | $1.48 | $0.62 |
| Total cost of small billets per G.T. | $17.04 | $23.66 | $6.62 |

## Estimated Cost of Merchant Bars—(Per G.T.)

(Base sizes including small structural shapes.)

| | | | |
|---|---|---|---|
| Average cost of large and small billets.. | $16.61 | $22.92 | $6.31 |
| Lbs. of billets used per 100 lb. of bars | 115 lb. | 115 lb. | .... |
| Lbs. of scrap recovered per 100 lb. of bars | 12 lb. | 12 lb. | .... |
| Cost of waste | $1.17 | $2.12 | .... |
| Cost of labor | 2.25 | 4.00 | .... |
| Cost of fuel | .35 | .60 | .... |
| Expenses | 1.30 | 2.75 | .... |
| | $5.07 | $9.47 | $4.40 |
| Total cost of merchant bars per G.T. | $21.68 | $32.39 | $10.71 |
| Total cost of merchant bars per 100 lb.. | .968 | 1.44 | .40 |



Works of Canadian Allis-Chalmers, Limited, at Toronto, Ont.

**Don't forget to fill out and return the Pink Slip — See page 32.**

| Merchant Bars Selling Price (Pittsburgh Base) | Average. | Minimum. | Aver. Price of Imports of Merchant Bars (Including Extras) | All Countries. | United States. |
|---|---|---|---|---|---|
| 1912 | $1.25 | $1.10 | Year to March 1913 | $1.45 | $1.40 |
| 1913 | 1.38 | 1.22 | Year to March 1914 | 1.55 | 1.50 |
| 1914 | 1.15 | 1.05 | Year to March 1915 | 1.44 | 1.40 |
| 1915 | 1.31 | 1.10 | Year to March 1916 | 1.81 | 1.81 |
| 1916 | 2.48 | 1.87 | Year to March 1917 | 2.65 | 2.65 |

| Large Billets (Per G.T.) | | | Average Price of Imports of Light Structural Sections. | | |
|---|---|---|---|---|---|
| 1912 | 22.74 | 19.40 | Year to March 1913 | 1.40 | 1.40 |
| 1913 | 25.56 | 20.00 | Year to March 1914 | 1.96 | 1.96 |
| 1914 | 20.08 | 19.00 | Year to March 1915 | 1.34 | 1.33 |
| 1915 | 23.14 | 19.00 | Year to March 1916 | 1.51 | 1.51 |
| 1916 | 45.02 | 35.50 | Year to March 1917 | 2.79 | 2.79 |

## Estimated Cost of Sheared Plates—(Per G.T.)

| | United States. | Canada. | Difference. |
|---|---|---|---|
| Cost of ingots per G.T. | $13.95 | $18.30 | $4.35 |
| Lbs. of ingots used per 100 lb. of slabs.. | 119 lb. | 119 lb. | .... |
| Lbs. of scrap recovered per 100 lb. of slabs at $11.00 per G.T. | 15 lb. | 15 lb. | .... |

### Cost of Slabs.

| | | | |
|---|---|---|---|
| Cost of waste | $1.01 | $1.83 | .... |
| Cost of labor | .40 | .55 | .... |
| Cost of fuel | .10* | .50x | .... |
| Expenses | .40 | 1.00 | .... |
| | $1.91 | $3.88 | $1.97 |
| Total cost of slabs | $15.86 | $22.18 | $6.32 |

* Natural Gas. x Prod. Gas.

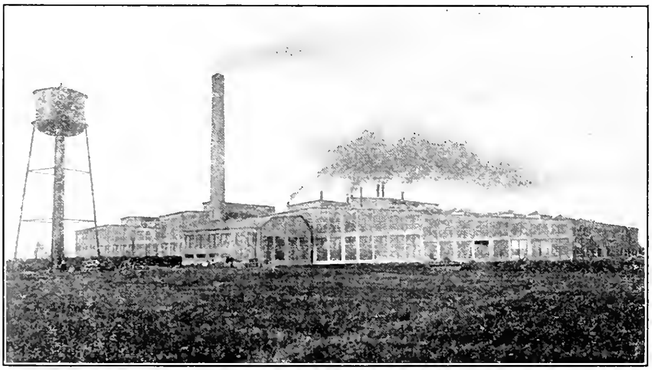
| | | | |
|---|---|---|---|
| Cost of waste | $ .90 | 1.78 | .... |
| Cost of labor | 1.45 | 2.00 | .... |
| Cost of fuel | .40* | .50x | .... |
| Expenses | 1.35 | 1.90 | .... |
| | $4.10 | $6.18 | $2.08 |
| Total cost of universal plates per G.T. | $19.96 | $28.36 | $8.40 |
| Total cost of universal plates per 100 lb.. | .892 | 1.265 | 3.73 |

* Natural Gas. x Prod. Gas.

| Selling Prices— United States (Base) | Average. | Minimum. | Av'ge Price of Imports into Canada Year to March 31st | Univ. Over 12″ | Not Less 30″x¼″ | Boiler Plates Not Less 30″x¼″ |
|---|---|---|---|---|---|---|
| 1912 | $1.30 | $1.11 | 1913 | 1.32 | 1.37 | 1.54 |
| 1913 | 1.41 | 1.20 | 1914 | 1.41 | 1.47 | 1.60 |
| 1914 | 1.41 | 1.05 | 1915 | 1.46 | 1.49 | 1.40 |
| 1915 | 1.29 | 1.10 | 1916 | 1.79 | 1.66 | 1.58 |
| 1916 | 2.82 | 1.90 | 1917 | 3.27 | 3.30 | 3.79 |

## Estimated Cost of Wire Rods—(Per G.T.)

| | United States. | Canada. | Difference. |
|---|---|---|---|
| Small billets | $17.04 | $23.66 | $6.62 |
| Waste (105% of billets used) | .53 | .85 | .... |
| Labor | 1.50 | 1.75 | .... |
| Fuel | .35 | .65 | .... |
| Other expenses | 1.50 | 1.60 | .... |
| | $3.88 | $4.85 | $0.97 |
| Cost of wire rods per G.T. | $20.92 | $28.51 | $7.59 |



**Works of Armstrong, Whitworth of Canada, Ltd., at Longueuil, Que.**

### Cost of Plates.

| | | | |
|---|---|---|---|
| Lbs. of slabs used per 100 lb. of sheared plates | 131 lb. | 131 lb. | .... |
| Lbs. of scrap recovered per 100 lb. of sheared plates at $11.00 per G.T. | 29 lb. | 29 lb. | .... |
| Cost of waste | $1.73 | $3.68 | .... |
| Cost of labor | 1.90 | 2.50 | .... |
| Cost of fuel | .30* | .50x | .... |
| Expenses | 1.45 | 2.00 | .... |
| | $5.38 | $8.68 | $3.30 |
| Total cost of sheared plates per G.T. | $21.24 | $30.86 | $9.62 |
| Total cost of sheared plates per 100 lb. | .948 | 1.38 | .35 |

* Natural Gas. x Prod. Gas.

## Estimated Cost of Universal Plates—(Per G.T.)

| | | | |
|---|---|---|---|
| Cost of slabs per G.T. | $15.86 | $22.18 | $6.32 |
| Lbs. of slabs used per 100 lb. of plates.. | 114 lb. | 114 lb. | .... |
| Lbs. of scrap recovered per 100 lb. of plate | 12 lb. | 12 lb. | .... |

| Selling Price (Pittsburgh) | Average. | Minimum. | Imports of Rods (Not Over ⅜″) Year to March. | N.T. | Price per G.T. |
|---|---|---|---|---|---|
| 1912 | $26.15 | $24.75 | 1913 | 91,919 | $26.10 |
| 1913 | 28.39 | 25.25 | 1914 | 69,806 | 27.10 |
| 1914 | 25.50 | 24.50 | 1915 | 65,587 | 25.00 |
| 1915 | 28.26 | 24.80 | 1916 | 61,750 | 30.60 |
| | | | 1917 | 52,300 | 56.00 |

## Estimated Cost of Black Sheets.

| | United States. | Canada. | Difference. |
|---|---|---|---|
| Cost of ingots per G.T. | $13.95 | $18.30 | $4.35 |
| Lbs. of ingots used per 100 lb. of sheet bars | 115 lb. | 115 lb. | .... |
| Lbs. of scrap recovered per 100 lb. of sheet bars | 12 lb. | 12 lb. | .... |

Don't forget to fill out and return the Pink Slip — See page 32.

**Cost of Sheet Bars.**

| | | | |
|---|---|---|---|
| Cost of waste | $0.78 | $1.42 | .... |
| Cost of labor | .85 | 1.30 | .... |
| Cost of fuel | .30 | .50 | .... |
| Expenses | 1.35 | 2.00 | .... |
| | $3.28 | $5.22 | $1.94 |
| Cost of sheet bars per G.T. | $17.23 | $23.52 | $6.29 |

**Cost of Black Sheets.**

| | | | |
|---|---|---|---|
| Lbs. of sheet bars used per 100 lb. of sheets | 116 lb. | 116 lb. | .... |
| Lbs. of scrap recovered per 100 lb. of sheets | 15 lb. | 15 lb. | .... |
| Cost of waste | 1.12 | 2.10 | .... |
| Cost of labor | 12.00 | 15.00 | .... |
| Cost of fuel | .60 | .90 | .... |
| Expenses | 3.90 | 4.50 | .... |
| | $17.62 | $22.50 | $4.88 |
| Cost of black sheets per G.T. | $34.85 | $46.02 | $11.17 |
| Cost of black sheets per 100 lbs. | .555 | 2.06 | 5.05 |

| Selling Price—(Pittsburgh Base —28 Ge.) | | | Av'ge Price of Imports (14 Ge. and thinner) (From U.S.) | |
|---|---|---|---|---|
| | Average. | Minimum. | | |
| 1912 | $2.00 | $1.80 | Year ending March 31, 1913 | $2.32 |
| 1913 | 2.20 | 1.85 | Year ending March 31, 1914 | 2.43 |
| 1914 | 1.89 | 1.80 | Year ending March 31, 1915 | 2.16 |
| 1915 | 1.93 | 1.74 | Year ending March 31, 1916 | 2.25 |
| 1916 | 3.06 | 2.65 | Year ending March 31, 1917 | 3.54 |

### Total Freight on Ore, Coke, and Foundry Pig Iron (Per G.T.)

| From | Sault Ste. Marie. | Hamilton. | Pt. Colborne. | Buffalo. |
|---|---|---|---|---|
| Freight on ore and coke to furnace, per ton of iron | $3.44 | $4.98 | $3.88 | $3.22 |
| Total freight to | | | | |
| Head of Lakes | 6.44 | 9.03 | 7.93 | 7.27 |
| Hamilton | 5.94 | 4.98 | 4.88 | 4.22 |
| Toronto | 5.69 | 5.83 | 4.98 | 4.32 |
| Montreal | 6.69 | 6.98 | 6.03 | 5.37 |

### Total Freight on Ore, Coke and Steel Products—(Per G.T.)

(Bars, Plates, Shapes, etc.)

Based on ½ ton of pig iron to 1 ton of steel.

| From | Sault Ste. Marie. | Hamilton. | Sydney. | Pittsburgh. | Chicago. |
|---|---|---|---|---|---|
| Freight on ore and coke to furnace per ton of steel | $1.50 | $2.25 | $0.25 | $1.65 | $1.50 |
| Total freight to | | | | | |
| Head of Lakes | 4.86 | 6.17 | 8.87 | 6.63 | 6.48 |
| Walkerville | 6.43 | 5.72 | 8.00 | 5.17 | 5.02 |
| Hamilton | 9.56 | 2.25 | 7.31 | 5.88 | 5.73 |
| Toronto | 9.56 | 4.04 | 7.09 | 5.88 | 5.73 |
| Montreal | 6.43 | 5.83 | 4.95 | 6.83 | 8.56 |
| Export—Montreal | 5.28 (Mtl.) | 5.16 (Hal.) | 3.05 | | |
| Export—New York | .... | 5.54 | .... | 4.11 | 6.20 |

### Total Freight on Ore, Coke and Wire Products—(Per N.T.)

| From | Hamilton. | Sydney. | Pittsburgh. | Buffalo and Cleveland. |
|---|---|---|---|---|
| Total freight on ore and coke to furnace per ton of steel | $2.25 | $0.25 | $1.65 | $3.22 |
| Total freight to | | | | |
| Head of Lakes | 6.17 | 8.87 | 6.63 | 5.96 |
| London | 5.16 | 7.87 | 5.88 | 6.51 |
| Hamilton | 2.16 | 7.31 | 5.88 | 6.51 |
| Toronto | 4.04 | 8.08 | 5.88 | 7.24 |
| Montreal | 6.40 | 4.95 | 6.83 | 8.44 |
| Export—Montreal | 5.16 (Hal.) | 3.05 | .... | .... |
| Export—New York | 5.54 | .... | 4.11 | 5.68 |

### Freight Rates.

| From | Ore per G.T. rail incl. handling. Boat. | Rail. | Coke per N.T. (or Coal per ton Coke) |
|---|---|---|---|
| To Sault Ste. Marie | $0.30 | $0.10 | $2.20 |
| Hamilton | .60 | .65 | 2.40 |
| Pt. Colborne | .40 | .10 | 2.40 |
| Buffalo | .40 | .10 | 1.85 |
| Pittsburgh | .40 | .88 | .75 |
| Chicago | .40 | .10 | (Penn) 2.50 (Ill. & Ind.) 1.20 |
| Sydney (Est.) | .20 | .... | .10 |

**Pig Iron—(Per G.T.)**

| From | Sault Ste. Marie. | Hamilton. | Port Colborne. | Buffalo. |
|---|---|---|---|---|
| To head of Lakes (Boat) | $3.00 | $4.05 | $4.05 | $2.45 |
| Hamilton | 2.50 | .... | 1.00 | 1.32 |
| Toronto | 2.25 | .85 | 1.10 | 1.58 |
| Montreal | 3.25 | 2.00 | 2.15 | 2.94 |

Rail from head of Lakes to Winnipeg, $3.01; Calgary, $9.00; Vancouver, $11.20.

**Rolled Steel Products.**

(Bars, Plates and Shapes, per 100 lb.)

| From | Sault Ste. Marie. | Hamilton. | Sydney. | Pittsburgh. | Chicago. |
|---|---|---|---|---|---|
| To head of Lakes (Boat) | 15 | 17½ | 38½ | 22¼ | 20 |
| Walkerville (Rail) | 22 | 15½ | 35 | 17.7 | .. |
| Hamilton (Rail) | 18 | .. | 31½ | 18.9 | 18.9 |
| Toronto (Rail) | 18 | 8 | 30½ | 18.9 | 18.9 |
| Montreal | .. | .. | .. | .. | .. |
| Export—Montreal | 22 | 13 (Hal.) | 12½ | .. | 19 |
| Export—New York | .. | 14.7 | .. | 11 | 21 |

Rail from head of Lakes to Winnipeg, 32c; Calgary, 90c; Vancouver, 65c.

**Wire Products.**

(Wire Nails, etc., per 100 lb.)

| From | Hamilton. | Sydney | Pittsburgh. | Cleveland. |
|---|---|---|---|---|
| To head of Lakes | 17½ | 38½ | 22¼ | 12¼ |
| London | 13 | 34 | 18.9 | 14.7 |
| Hamilton | .. | 31½ | 18.9 | 14.7 |
| Toronto | 8 | 30½ | 18.9 | 17.9 |
| Montreal | 18½ | 21 | 23.1 | 23.1 |
| Export—Montreal | 13 | (Hal.) 12½ | .. | .. |
| Export—New York | 14.7 | .. | 11 | 11 |

## DISCUSSION.

**Mr. F. P. Jones**:—I have had the privilege of reading Mr. Whitton's paper, and I wish to thank him for the trouble, the thought, and the work he has put into the effort. In point of national importance, the iron and steel industry occupies a pre-eminent position. If Canada is to take her place as a manufacturing nation, an iron and steel industry is a pre-requisite. But if Mr. Whitton's calculations and statements are to be accepted as correct, I fail to see how a successful iron and steel industry can be established in Canada. His calculations have, I think, been made on a wrong basis. First of all he takes the production of pig iron in Canada during 1912, as 913,000 tons or 77.7 per cent. of the amount Canada consumed, and in 1913, as 1,015,000 tons or only 74.8 per cent. of the Canadian consumption. Here Mr. Whitton has represented the theoretical producing capacity and not the actual. Not only that, we have a number of furnaces in Canada that are not equipped to operate. Take the Dominion Iron and Steel Company; Mr. Whitton places its present capacity at 550,000 tons and its maximum production at 350,000 tons. I contend that in 1913 Canada produced every pound of pig iron that it was possible for her manufacturers to turn out, and instead of 77 per cent. the furnaces were operated at practically full capacity. As to the figures Mr. Whitton gives in connection with producing capacity, we have no actual statistics of pig iron in Canada, but there is a shortage instead of a surplus. That is shown in his statistics of the imports. The Steel Company of Canada has a pig iron capacity of 200,000 tons and can use every pound of their own pig iron. As a matter of fact, the Dominion Iron and Steel Company never

**Don't forget to fill out and return the Pink Slip — See page 32.**

would use over 355,000 tons; while the Nova Scotia Steel capacity is 90,000 tons. However, to be brief, I think on Mr. Whitton's own figures it is fair to assume that we are not in a position to market pig iron, or even to meet our own present requirements.

Then as to wire rods. Mr. Whitton gives the production in Canada in 1915, of rods as 114,800 tons and stated that we used in Canada 179,000 tons. That statement is absolutely misleading. The Dominion Iron and Steel Company has one rod mill producing 90,000 tons of rods in a year. The Steel Company of Canada has a rod mill which can produce more rods than Canada has ever consumed. These companies could have produced all the rods that were needed, but they put their steel into other products. In estimating the cost I think Mr. Whitton has been unintentionally unfair. He selects for comparison the Lackawanna plant and the plant of the United States Steel Corporation—two of the greatest producing plants in the United States. He compares them with plants in Ontario. These two United States' plants probably can produce more cheaply than any other plants in the world, while the plants in Ontario, have the highest operating costs of any plants in Canada. Ontario, has however, something to offset the high cost; it is nearer the big consuming markets. It would have been fair to compare the American cost with that in Nova Scotia. Had this been done the showing would have been very different. Mr. Whitton goes into details as to labor for making pig iron, but I am unable to follow his figures. He states that scrap is cheaper in the United States than in Canada; I do not think that is correct. Scrap is just as cheap in Canada. Canada is exporting scrap to the United States to-day. Mr. Whitton says that it costs $5.24 a ton more to make rails and billets in Canada than in the United States. Algoma and Sydney have exported rails to the United States and have undersold American producers in their own country. The Canadian companies that did this have either made a tremendous loss or Mr. Whitton's figures are wrong. Canada, I am satisfied, will be an iron and steel producing country, but the way to build up the industry is to make provision for additional production in the one line where we are short, and not to scatter our energy by getting into competitions with existing mills.

**Mr. G. A. Irwin** (Algoma Steel Company):—As regards the steel industry in this country, it may be remarked that while the companies operating in Canada have passed through several lean years, they have during the past two years been remarkably successful, due principally to the shell steel industry; and I am confident that the future shows much promise. I have in my hands the latest Government records, and to give an idea of the advancement in this Canadian industry, I would point out that whereas our production of steel in the shape of ingots and castings amounted to less than 20,000 net tons in 1895, the production in 1913 (the last year of normal conditions and for which figures are available) shows 1,169,000 net tons. This on the face of it would indicate marked prosperity; but if we look at the matter from another standpoint we shall find that while Canadian production is rapidly increasing, it is still far short of our own requirements, as is shown by the fact that whereas imports of iron and steel products in Canada in 1895 were less than $10,000,000 in value, imports in 1913 were close to $150,000,000 in value. The bulk of these imports are in the shape of structural steel, plates, sheets and bars. Up to the present Canada has not made plates or sheets in any considerable quantity and has only manufactured structural shapes in the smaller sizes which are protected by a duty of $7.00 per ton. In 1914 the Canadian Government adopted a tariff resolution authorizing the Governor in Council, when satisfied that rolled iron or steel angles, beams, channels, and other rolled sections or shapes were being manufactured in Canada in substantial quantities, to impose upon such shapes up to the weight of 120 lb. per lineal yard, the tariff of $7.00 per ton now effective on lighter shapes namely 35 lbs. per lineal yard and under, instead of $3.00 per ton as at present existing. This action on the part of the Government has resulted in Canadian steel makers giving serious consideration to the installation of heavy structural mills and it is very probable that within the next year or two Canadian mills will be producing a very considerable portion of the requirements of this country in respect of structural shapes of all sizes.

The Algoma Steel Corporation, Limited, with its works at Sault Ste. Marie, Ontario, has been increasing its steel capacity considerably of late and it is anticipated that when present improvements shall be completed we will have an output of about 50,000 tons of ingots per month. The mills at the Soo were started primarily for the production of heavy rails, the demand for which was then great in Canada. With our increasing steel production we must manufacture a more diversified product to find a ready market, and serious consideration is being given to other lines which it would be best to undertake. I believe that other steel companies are considering the manufacture of fresh products and these developments will all assist in making Canada more self-supporting than in the past.

I have reason to believe that more than one company in Canada is considering the installation of a plate mill, especially in view of the probable increase in shipbuilding which will necessitate the use of a large tonnage of steel plates. In 1913, 3,565,000 net tons of plates and sheets were imported into Canada, and it is reasonable to expect that the consumption in this country will increase rapidly once business conditions shall become normal. I do not desire to discuss politics, but would mention that one reason why Canada has not gone into the manufacture of plates and sheets has been the non-uniform tariff. Boiler plates enter Canada free of duty, and plates for the manufacture of ships obtain a rebate of 99 per cent. of the duty, so that a very considerable portion of the plate tonnage now consumed enters this country practically duty free. To operate a plate mill successfully a large tonnage would be necessary, and until such time as Canadian makers can be assured of reasonable protection on all varieties of plates it will be difficult to induce capital to invest. I understand, that if the Canadian Government assists shipbuilding by bonus or otherwise, it may perhaps provide some protection for the manufacturers of the steel plates which will be required. Were this done, it would materially alter the situation and give much greater encouragement to prospective Canadian manufacturers than now exists.

The manufacture of sheets is somewhat intricate. Sheets are produced in many qualities — plain black, galvanized, polished, planished, etc. They require to be carefully prepared and carefully packed, and the successful production of sheets requires highly-skilled labor which would be difficult to obtain and hold in Canada. Sheets at present enter Canada from Great

Britain free of duty, with a duty of only 5 per cent. from the United States, and we could hardly hope to compete successfully against the large mills in England and the United States on the present basis. A protective tariff would need to be assured before Canadian mills would undertake the production of sheets.

Our Government friends have not given a fair show to the makers of wire and wire rods. For many years wire rod manufacturers were assisted by a bounty but this has been withdrawn within recent years and, further, the tariff has been altered to permit of the free entry into Canada of rods for use in the manufacture of galvanized wire. During the past couple of years large quantities of wire rods and wire have entered Canada from the United States; but I feel that with reasonable protection a great bulk of this tonnage would be produced in Canada.

As to the general up-building of the steel trade in this country, I agree with Mr. Jones that there is a bright future. Our friends in the East are to-day making handsome profits and so far as I can see they ought to be in a position to produce steel as cheaply as in any other centre in the world. With the enlargement of their present plant and the fact of their being on tide-water, they should be able not only to secure a fair share of the Canadian market but also to compete successfully for export trade. The Steel Company of Canada is exceptionally well situated from a standpoint of distribution. Their mills are in the most thickly populated section of Canada, where large steel tonnage is consumed, and even if their raw material does cost more than at Sydney or the Soo, they have the advantage in distribution.

As you are well aware, the steel manufacturing plants in Canada have, during the past year, been occupied largely in the manufacture of a high-grade steel for munition purposes and I am pleased to be able to state that Canadian mills have been very successful in manufacturing a product which is second to none. The technical experience gained in producing this special steel will be of greater benefit to the operating departments of our mills, and should result in Canada being in a much stronger position after the war than heretofore. The important thing for us is to enlarge our plants along the right lines so as to be able to take care of the requirements of the country to the fullest possible extent once normal business conditions shall return. I feel sure that this question is being given a most careful searching investigation by all of the leading Canadian companies.

**Mr. J. G. Morrow:**—I agree heartily with what Mr. Jones and Mr. Irwin have said in regard to co-operation and experience in the iron and steel industry in Canada. There are two or three angles from which we must regard this problem and I think Mr. Whitton has presented it from one angle and Mr. Jones from another. In the case of pig iron, the Hamilton works of the Steel Company of Canada is in close proximity to a large number of manufacturing companies. Some of these are producers of agricultural implements, and pig iron is one of the largest of their importations. For agricultural purposes, this pig iron comes into Canada, with a drawback duty, and they get all the duty refunded except one per cent. Under these conditions we are in open competition with the cheapest makers of pig iron in the world.

In regard to scrap, we had a condition not normal in Canada. We exported scrap because we had an excess and we had not the furnace capacity to use it.

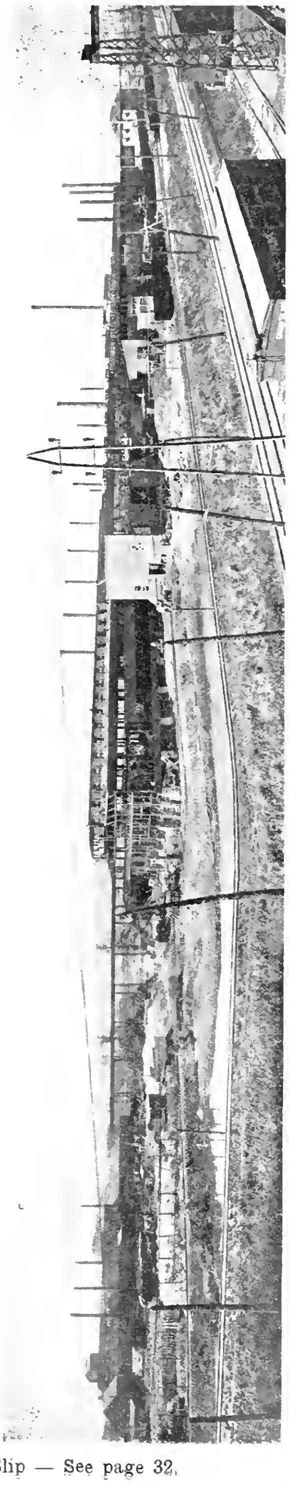


**Photo of plant of Dominion Steel Foundry Co., Limited, Hamilton, Ont.**

Since this photo was taken several large and important additions have been made including the plate mill.

**Don't forget to fill out and return the Pink Slip — See page 32.**

With the inauguration of a number of plants, especially electric, the consumption of this material has been increased, and we are now able to take care of all and possibly more than we can produce. Mr. Whitton, I know, has based his calculations on the reports issued by the Governments of Canada and of the United States through the proper departments, so that I am confident that in the main his figures are correct. It must not be assumed that pessimism is the keynote of Mr. Whitton's paper; neither, I take it, is optimism alone sounded in Mr. Jones' address, but I am sure that if the iron and steel industries of Canada will co-operate on some sort of basis for the consideration of their joint interests, to enable them to produce new products and to distribute them economically, many facts which at present seem unreal will be demonstrated and made clear, and with co-operation proper Governmental measures for greater development in the iron and steel industry in Canada may be forthcoming.

**Dr. J. B. Porter**: It must be realized that the importance of the steel industry cannot be exaggerated, and the present occasion, and particularly these two interesting papers that are being discussed, give the Institute an exceptional opportunity for bringing the matter before the public and incidentally before the governing authorities.

**Mr. J. A. Dresser**:—The paper of Mr. Whitton seems to have a national bearing and, very properly, is being discussed in that light. The aim is to get the Dominion into a self-contained position in respect of its raw materials for the production of iron and steel. This brings us back to the unfortunate position which we had to consider some three years ago, when it was fully realized that our known supply of iron ore that could be used in its natural state was altogether insufficient to meet our needs in iron and steel. Since that time our consumption has increased enormously, the production only slightly, and consequently the general condition is less favorable than before.

Certain ores, or "near ores," exist in large quantities, but nearly all have to be beneficiated in one way or another to make them fit for use in the blast furnace. Titanium bearing ores are abundant, especially in Quebec, but their profitable reduction has not yet been accomplished. The 'banded' iron ores which are in immense quantities in Ontario, are high in finely intermingled silicates, and require mechanical concentration. Magnetite containing sulphur above smelting limits is found in large quantities, but it requires roasting to remove the sulphur. Siderite, which is already mined in quantity in the Michipicoten district of Ontario, requires to be calcined and in parts further roasted when there is an excess of sulphur. All of these ores require treatment after mining to fit them for furnace use.

Apparently the best attempt to utilize such ores has been that made by The Algoma Steel Corporation of Sault Ste. Marie in treating the siderite of Michipicoten, where more than 200,000 tons have been produced during the past year. This has been done under conditions of high labor costs, but in a favorable market. In brief, it may be said that the operation has attained a measure of success, but still needs improvement to assure its permanent and most economical use. Important efforts have also been made to utilize the other classes of ore that I have mentioned, particularly those of Moose Mountain, Ontario; but at present these efforts are somewhat in abeyance. On the whole, it certainly appears that the effort to provide a domestic supply of iron ore that is most likely of success lies in the way of utilizing, even at a minimum profit, these ores that we know we have in large quantities. The need and opportunity for investigation along this line will not, I am sure, escape the attention of the Honorary Advisory Council for Industrial Research.

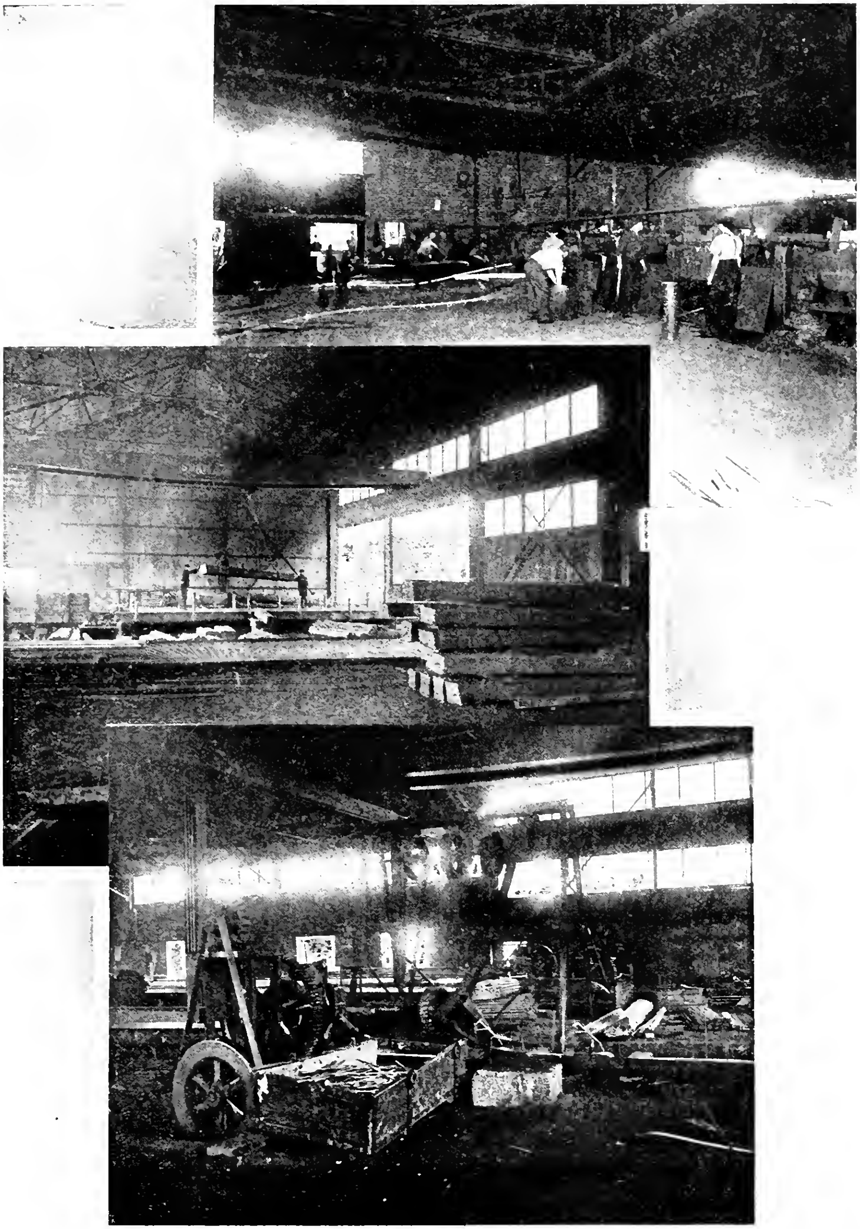
The utilization of the ores we have would inevitably lead to more thorough examination of the deposits we already know, and to prospecting for others. Such detailed examination accompanying mining operations might also disclose concentrations, even though relatively small, or ore of higher grade such as the now nearly exhausted Helen mine of Michipicoten. Neither the prospector nor the geologist can hope or be expected to find in unworked territory either all or the best that it may ultimately produce. Our immediate hope, if any, seems to be in the ores we have in quantity. The prospects are not rosy but they are the best we have of getting a domestic supply of iron ore in eastern Canada.

**Mr. T. R. Drummond**:—I can only speak from a prospector's point of view. I do not pretend to be an authority in any way, but I would like to say a few words about the iron region of the western part of the district of Sudbury. I can say that there is a large amount of what is at present known as low-grade iron ore existing there for about forty miles, and with a width of from 500 to 1,000 feet. Much is massive magnetite, and still farther along is what may possibly develop as hematite ore. Whether these ores exist in very large quantities or not is another question; but there is a considerable amount of ore containing from 40 per cent. to possibly 45 per cent. of iron. It is absolutely free from titanium and reasonably free from phosphorous and low in sulphur; three important requisites. There is also apparently a considerable amount of ore that would average over 50 per cent. of iron.

**Mr. Belknap**:—I represent one of the smallest iron industries in Canada, the Standard Iron Co., Limited, with a blast furnace at Deseronto. We have been making charcoal iron there for the last four or five years with more or less success, but there have been difficulties in assembling the raw material. We have experimented at Deseronto with one or two Canadian ores, one of these being a concentrate from the Moose Mountain mine, but up to the present time without any material success. The proportion of phosphorus and sulphur in this concentrate is so much higher than in Lake Superior ore that it is impossible to meet the specification for low phosphorus iron or even standard bessemer. The Moose Mountain people are experimenting with their ore and have succeeded in reducing the sulphur to a great extent through sintering, but they have not yet been able to get the phosphorus sufficiently low even to meet the standard Bessemer specification. To conduct experiments of this nature on an adequate scale is beyond the scope of any one concern, and it appears to me to be a matter that the Government should initiate on some large and definite scale. They have, I know, made many experiments at Ottawa in regard to different ores around the country, especially in Ontario, but in our experience have never reached any definite or satisfactory conclusion.

**Mr. C. F. Whitton**:—(Communication to the Secretary). In reference to Mr. Jones' remarks I desire to submit the following reply:

**Don't forget to fill out and return the Pink Slip — See page 32.**



Three interior views of The Burlington Steel Company, Ltd., Hamilton, Ont.

Don't forget to fill out and return the Pink Slip — See page 32.

### Figures and Authorities.

The figures for the production of pig iron and various steel products have been extracted direct from the bulletins issued by the Department of Mines and the American Iron and Steel Institute, all of which are compiled from the data furnished them by the producers of iron and steel. I do not think, therefore, that the figures representing actual production can seriously be questioned. Figures representing imports have been compiled from the Government blue books and are unquestionably accurate as far as the classifications permit.

### Capacities of Blast Furnaces.

Mr. Jones doubts the accuracy of my figures showing the relation of the production of pig iron in Canada to the total consumption in the country. The figures submitted in the various tables are compiled from the following sources which are believed to be reliable: Department of Mines, Annual Report specifying the number of furnaces at each plant, their capacity, and the number of days each furnace operated. It is an easy matter to calculate from these data the total capacity and production of each plant, and these figures have been made to agree in the aggregate with the total reported production of the country. The data have also been checked, and other information in regard to open-hearth plants, rolling mills, and other finishing departments have been obtained, from the Iron and Steel Works Directory which is issued by the American Iron and Steel Institute.

### Comparison of the Total Production and Consumption of Pig Iron in Canada.

The writer must admit having erred in the figures showing the ration of production to capacity. The calculations were based on the present capacity of active blast furnaces, and the increase in capacity due to the building of new furnaces in the year 1913 was overlooked. I have therefore revised the calculations on the basis of the actual capacity of blast furnaces active in the various years, which are shown separately under Ontario and Nova Scotia production. The percentages are now as follows:

| | |
|---|---|
| 1912 | 74.0% |
| 1913 | 78.2% |
| 1914 | 48.5% |
| 1915 | 56.5% |
| 1916 | 71.5% |

I do not think there should be any doubt as to the producing capacity of these blast furnaces; and taking the number of days which each furnace has been reported in blast during the various years, I find that the total production of each plant and all the plants together agree fairly closely with the tonnages reported by each company annually to the Statistical Bureau and also published in their annual reports. Few furnaces, if any, run continuously throughout a year and produce their normal rated tonnage. On looking over the annual reports, I find that in 1913 at the four large blast furnace plants in Canada, comprising 12 blast furnaces, 7 furnaces were out of blast a total of 317 days or 7 per cent. of the whole, although that year was the biggest pig iron year before 1916. In 1914, three of these furnaces were idle all year and seven others lost 1,068 days, a total of 2 163 days or 46 per cent. of the total possible operating time. In 1915 five furnaces lost 1,314 days or 30 per cent. of the possible operating time. In 1916 four furnaces lost 785 days or 18 per cent. of the whole. I do not think there is any doubt but that these conditions actually represent true operating conditions in past years in Canada, as the pig iron statistics of the United States show that practically the same conditions existed there in the years 1914 and 1915, when their pig iron production dropped to 23,000,000 tons as against an average production of 30,000,000 for previous years, and 40,000,000 tons in 1916. A large increase in the rate of production of pig iron in the United States in the last half of 1915, indicated that their blast furnaces had only been operating up to that time at a normal rate but when hard pushed, they could get out an additional 10 per cent. of their normal tonnage, this rate having been maintained practically ever since. My contention is, that in Canada we have sufficient blast furnace capacity to take care of our past maximum requirements and our present and immediately future requirements if these furnaces are operated on an economical basis and at full production as is being done in the States. In regard to the individual plants, Mr. Jones does not explain why the Dominion Iron and Steel Company has never produced more than 350,000 tons of pig iron in any year although the company has had six blast furnaces available since 1913. I do not think that he would maintain that they cannot produce more than this tonnage. The Algoma Steel Company has operated its furnaces nearly continuously, and yet its production for the 12 months ending June, 1915, was only 213,000 tons, against 312,000 tons produced in the previous 12 months. These facts are difficult to understand unless we know the actual conditions under which these Companies have been operating.

The Steel Company of Canada's record of production is given in the same table with the other steel companies, and I can only say in explanation of the small tonnage produced as compared with capacity, that the number of days lost by our blast furnaces has been due to various causes such as relinings, explosions, business depressions, and in the past year, shortage of coke, all of which have probably affected other pig iron makers at various times.

I do not agree with Mr. Jones when he states that there is a shortage rather than a surplus of pig iron in Canada, either of steel making or foundry grades. Taking the present steel capacity of the various plants, as near as the writer can ascertain, the Algoma Steel Company has an approximate capacity of 50,000 N.T. a month or 600,000, N.T. a year. Inasmuch as their pig iron capacity is only 350,000 G.T., it is evident that it had sufficient pig iron only to operate its open-hearth furnaces on the straight open-hearth plan, but not by the duplex process; or about enough pig iron to operate the 20-ton Bessemer converter continuously and if desired, to duplex this metal. It is evident therefore that this company had no surplus of iron. As to the Steel Company of Canada, its present capacity is 400,000 N.T. of steel a year for which it would use about 150,000 tons of pig iron, assuming that scrap can be obtained cheap enough and in sufficient quantity to use a 40 per cent. pig iron and 60 per cent. scrap mix. Our furnaces have been producing pig iron at the rate of 200,000 tons annually as long as conditions and the supply of raw materials permitted, so that we expect to have a surplus of 50,000 tons or more of foundry pig iron for sale. The Dominion Iron and Steel Company's steel capacity is reported as 400,000 N.T. annually, its maximum production being 376,000 tons in

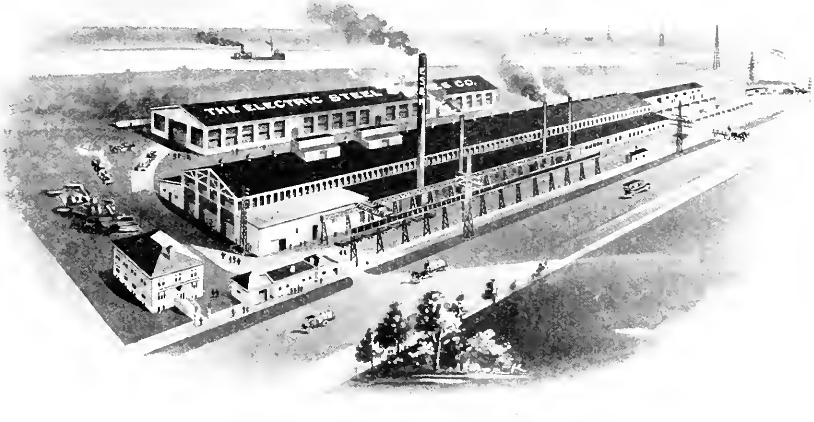
1916. Assuming that it would produce all the steel by the duplex process, it would require approximately the same tonnage of pig iron, which would leave the company a surplus, if operating its six blast furnaces at full capacity, of about 175,000 tons. This should afford the company an opportunity to enlarge the steel plant and find an export market for an increased tonnage of finished products.

Taking the consumption of pig iron for steel making as a whole, we find in the report of the Bureau of Mines for 1915, that the maximum consumption for steel making in 1913 was 913,000 N.T., corresponding to an ingot production of 1,170,000 N.T. The production of ingots in 1916 was 1,170,000 N.T. and it is presumed that the pig iron used would be approximately the same as used in 1913. The total steel capacity of the various large plants is now close on to 1,500,000 tons, or about 330,000 tons in excess of the 1916 production, so that the amount of pig iron required would therefore be about 130,000 N.T. greater than in 1913, or 1,045,000 N.T., which is equivalent to 935,000 G.T. of steel-making pig iron.

Assuming the total capacity of blast furnaces at present active and able to operate as 1,500,000 tons, which I think is a fair estimate, there should be a surplus pig iron capacity above requirements for steel-making of nearly half a million tons. The fact that Canada imported a considerable tonnage of foundry pig iron in 1912 and 1913 does not prove that there was a shortage of pig iron in those years, because there was then a pig iron producing capacity almost equal to what exists now, and if market conditions had permitted, the Canadian producers would have been able to fill all the Canadian requirements of foundry pig iron. The present severe shortage of foundry pig iron, both in Canada and the United States, is due not so much to an increase in demand for this grade of pig iron but to the great shortage of raw materials and the excessive demand for steel making pig iron. When this condition is removed there is no doubt that Canadian producers can take care of all the Canadian demand for foundry pig iron.

### Wire Rods.

There can be no doubt as to the accuracy of the figures of wire rod production and consumption in Canada as shown in the table. Since the year 1913, in which the Steel Company of Canada's rod mill was built, it has never been able to run the mill double turn on account of low market conditions in the States and the absence of protection. In the middle of 1914, however, a duty of \$3.50 a N.T. was granted by the government, except on wire rods for the manufacture of wire fencing, which is admitted free. Owing to the scarcity of steel, we could have operated our rod mill double turn, as the Dominion Iron and Steel Company has done since 1915 (owing to the large export market thrown open to them) except for the fact that our steel capacity was needed for other purposes, principally munitions. When the demand for munitions ceases, we expect to run our rod mill double turn and supply as large a proportion of the home market requirements as we can under the present tariff and market conditions.




Plant of The Electric Steel and Metal Co., Welland, Ont.

Mr. Jones' statement that the Dominion Iron and Steel Company can produce 90,000 tons of rods a year is correct; in 1916 it produced 112,000 tons of which about half was exported. The Steel Company's rod mill, however, cannot produce more than 120,000 N.T. a year, which is a long way short of Canada's total consumption.

### Costs.

The writer must admit that he has considered the subject of Canadian iron and steel industries principally from the point of view of the western industries, where we are continually in competition with the chief producers of iron and steel in the United States.

Don't forget to fill out and return the Pink Slip — See page 32.

All the cost figures have been based on conditions which obtain in Ontario, as the writer was able to obtain reliable data in regard to the cost of ore, coke, transportation and conversion costs for this district but was unable to even hazard a guess in regard to the cost of producing iron and steel products at the Atlantic seaboard. I hope the figures are understood to cover only such grounds as I have mentioned, and I trust that those who are able to present similar data in regard to the Nova Scotia industries will do so, as the information is needed for an intelligent consideration of the whole question.

Mr. Jones, probably, has not had time to read or study the figures submitted in my paper showing the transportation costs on finished products from the various steel plants, including Sydney, to the principal market points in Canada; or the combined figures showing the cost of assembling raw materials at the various plants, added to the cost of transportation of their products to various districts.

I would like to draw attention to the situation of the several plants in regard to the various market districts.

To head of lakes, which includes goods shipped to the North West, Sault Ste. Marie shows the lowest total freight costs on ore, coal, and steel products of $4.86 a gross ton as against the next lowest cost at Hamilton of $6.17. The lowest American cost is at Chicago, $8.48.

For Hamilton and Toronto, Hamilton is the cheapest assembling point.

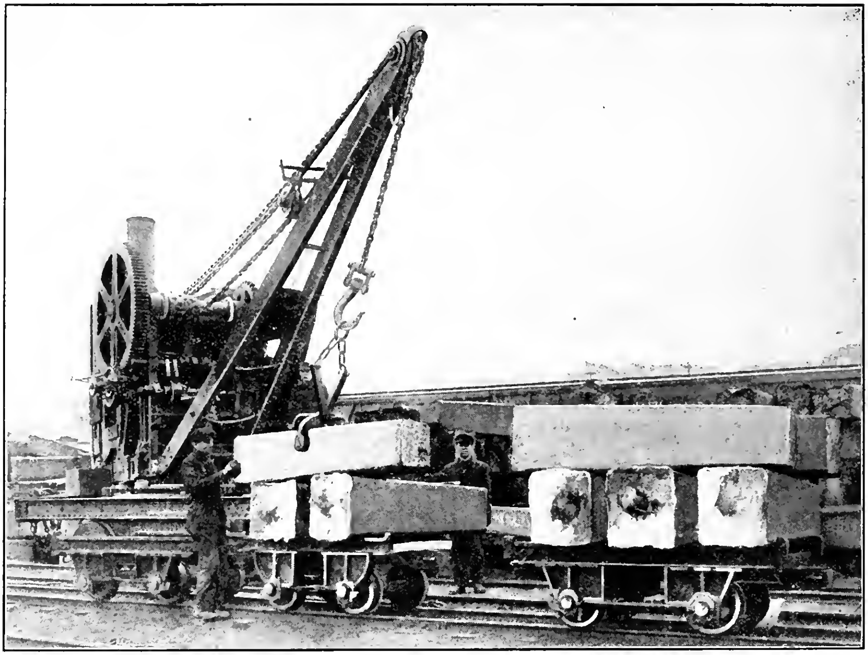
For Montreal, Sydney is the most favourable point, showing a cost of $4.95 against Hamilton $5.83, and Sault Ste. Marie $6.43; the lowest American cost to this point being that of Pittsburgh $6.83.

For export, I figure that Sydney's total assembling costs and freight to Halifax is $3.05 as against Pittsburgh to New York $4.11. There are other American steel companies on the Atlantic seaboard that bring their ores from foreign countries such as Cuba, South America, Spain, and Sweden, but I cannot hazard a guess as to their cost of assembling materials.

Comparing Hamilton and Sydney with Pittsburgh and Cleveland in regard to wire products, it will be seen that Hamilton's total assembling costs and freight on products is the cheapest to head of lakes, London, Hamilton and Toronto; but Sydney's are the lowest to Montreal and for export.

I heartily agree with Mr. Jones in his recommendation that iron and steel industries in Canada should co-operate on a closer basis for the purpose of discussing and considering their joint interests in regard to extensions of plants, the manufacture of new lines, distributing tonnage to the best economical effect, and avoiding useless competition. Also they could use their associated efforts in presenting to the Government a clearer and more comprehensive view as to the actual protective measures needed for the development of Canadian iron and steel industries.

I do not think it is unfair to compare our situation here in the central part of Canada with the other large industries in the States similarly situated, with regard to supplies of ore and coal, and also their product markets. When you attempt to consider a broad question such as an analysis of the iron and steel industry in Canada, one does not gain anything by

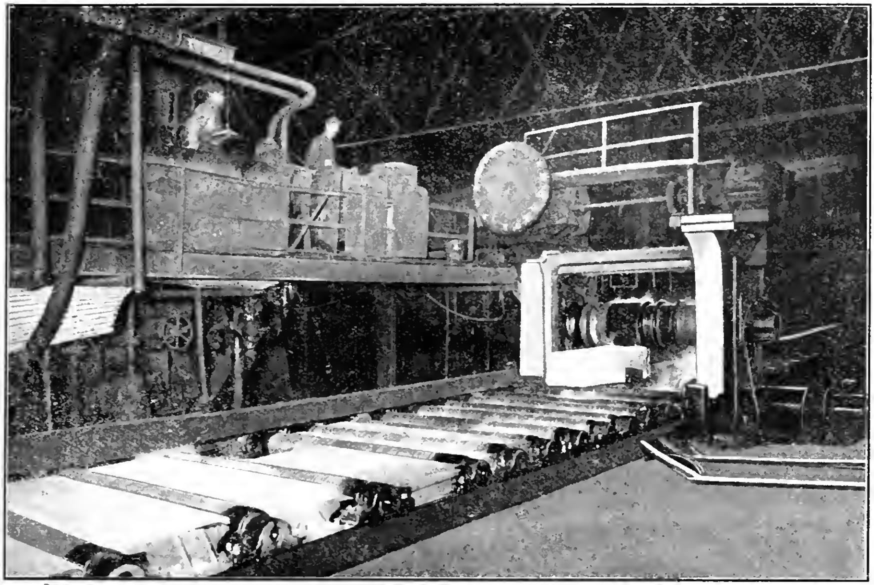


Loading 3½ ton steel ingots in the yards of the Nova Scotia Steel & Coal Co., at New Glasgow, from cars onto small trucks

**Don't forget to fill out and return the Pink Slip — See page 32.**

closing one's eyes to the fact that the large steel companies of the United States are able to produce their ore and coal and their semi-finished and finished products at much lower costs than Canadian producers. In order to have the intelligent grasp of the whole situation, one must take all these factors into account, and I think that we are better off in appreciating the exact conditions confronting us rather than in trying to hide them. Either we are going to develop the iron and steel industry in Canada, or these larger American concerns are going to cover the field.

No one who has any knowledge of the iron and steel industry in Canada can doubt that the Nova Scotia plants have probably as cheap facilities for assembling raw materials as any plants in the world, and should be able to compete successfully in export and Eastern American markets with either Pittsburgh or the southern States' plants. On account of their situation on the seaboard, they are also able to compete successfully on the Pacific seaboard with these and any other producers in the world, and there is no doubt that they have been able to place rails in the United States at a profitable price at times when conditions in Canada permitted them to export rails. Of course both Algoma and Sydney have always had the advantage of a very fair protection in Canada and have been aided in selling rails in the United States, owing to the fact that for years there has existed a rail selling pool, which has fixed the price at $28.00. Of course American rail producers have been earning large profits on rails, as they probably do not cost the largest producers more than $17.00 a ton, the principal reason being that the railroads and government were content to allow the steel producers a fairly large profit in order that the quality of rails might not suffer and that they might be afforded a sufficient margin in years when railroads were taking a large tonnage to tide them over long periods of shutdowns and depressions. I therefore do not think that my figures are far wrong or can be upset on the grounds that Canadian producers have been able to market their rails in the States. I think this is sufficient proof for the satisfaction of anyone who understands the conditions mentioned above. I wish that Mr. Jones, who has had a wide experience and reputation in the steel business, had considered and presented some figures in regard to the costs of assembling materials and of making pig iron and steel, after which there would not have been much doubt as to the correctness of the figures of costs of other finished products.



**View of rolling mill in the plant of the Nova Scotia Steel & Coal Co., Ltd., New Glasgow, showing a 3-ton heated ingot in the process of being cogged or rolled.**

From "The Iron Age" we cull an article on "Heat Treating Furnaces," from a pamphlet by the Standard Fuel Appliance Co., Detroit. This presents a comprehensive illustrated description of a line of heat treating furnaces using gas or oil as fuel. The features of construction which are common to all the furnaces are first brought out, followed by descriptions of the several different types. In each case a view of the exterior of the furnace is presented, together with a cross-sectional diagram showing the construction and arrangement of the various parts. The descriptive matter is further supplemented by a table of the different sizes that can be supplied. Mention is made of a line of accessories for use with the furnaces as well as some of the special types that have been designed to meet individual requirements. A number of views of installations and a partial list of users are included.

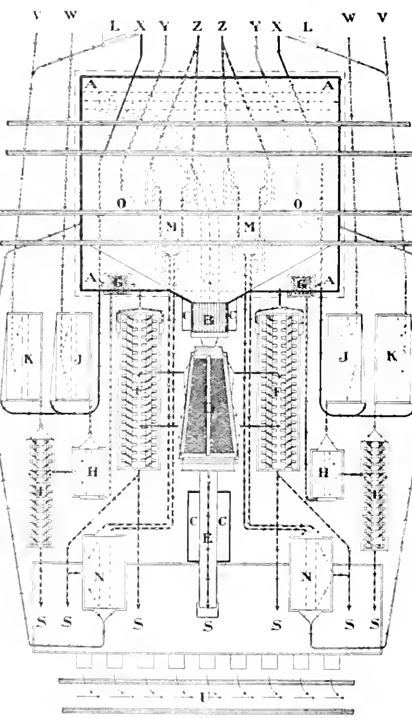
**Don't forget to fill out and return the Pink Slip — See page 32.**

# Iron Ore Washing Plants

(Allis-Chalmers Manufacturing Company.)

The occurrence in various parts of the United States and Canada of large bodies of iron ore too low in iron content to be smelted direct in the blast furnace at a profit, is of great economic importance to these countries. Undoubtedly from these sources the future supply of this most important commodity will be drawn when the great bodies of high grade ore now furnishing the bulk of the raw material to the blast furnace are insufficient for the demand.

The interest of the public in the conservation of natural resources and the interest of owners of such low grade ores is stimulated by the success of two milling plants installed on the Mesabi range in Minnesota for raising the grade of hitherto unprofitable ores. These mills are those of the Oliver Iron Mining Company near Coleraine, Minn., on the shore of Trout Lake, and of the Wisconsin Steel Company near Nashwauk, Minn., and a short distance from the shore of O'Brien Lake. The ores treated in both mills consist of a mechanical mixture of soft hematite and sand, with boulders of ore and paint rock and some clay, all loosely held together, and breaking up in handling.




Flow Sheet of Ore Washing Plant of the Oliver Iron Mining Co

Figure 1.

A. 500-ton crude ore receiving bin.
B. 7-in. grizzly bars.
C. Rock pocket.
D. 20 ft. 2 in. perforated conical screen.
E. 3 ft. picking belt.
F. 25 ft. log washer.
G. 36 in. x 4 ft. perforated chip trommel.
H. 5 ft. x 8 ft. settling tank.
I. 18 ft. turbo washer.
J-K 6 x 14 ft. settling tank.
L. Overstrom tables.
M. 10 x 54 in. Frenier pumps
N. 7 ft. x 12 ft. dewaterer.
O. 5 ft. x 6 ft. clear water tank.
S. Shipping bin.
T. Tail race.
U. Shipping track.
V. To first 5 Overstrom tables.
W. To last 5 Overstrom tables.
X. Overflow to waste.
Y. Wash water.
Z. Concentrates lifted by Frenier pumps to de-watering tanks.

The plant of the Oliver Company, which treats upwards of 1000 tons per hour, is an example of conservative construction, a plant designed for long life with a consequently low depreciation and maintenance charge, for low operating costs, and for reliability. The flow-sheet, Fig. 1 shows the passage of the ore through a single unit of the mill, there being five similar units. Leaving the ore bin "A" the ore flows over the grizzly "B," where a partial sorting takes place, waste being rejected into the pockets "C" and coarse ore being broken by hand to pass through the grizzly. The ore with the water used in sluicing it to the grizzly is fed into the revolving conical trommels "D," four feet in diameter at the feed and tapering to a diameter of eight feet in a total length of twenty feet. These trommels, Fig. 2, are especially designed for ironwashing service, very substantial in construction, carried on rollers so that there is an unobstructed opening through the trommel for the passage of the ore. It has few wearing parts and those capable of easy replacement, the screening surface is of perforated metal, which in this case has perforations two inches in diameter. After being washed by a spray of water inside the trommel, the oversize is discharged onto a short belt conveyor, "E," from which the waste is sorted out and dropped into further waste bins "C," the coarse ore going over the end of the conveyor into the shipping bin "S." The undersize from the two inch holes of the trommel is divided between two twenty-five foot patented Turbo Log Washers, "F," the coarser and heavier particles which constitute the ore being pushed over the shallow end into the shipping bins, while the sand and clay together with the finer particles of ore are carried by the high velocity of the water over the overflow at the deep end and pass through a chip screen "G" and a settling or sloughing-tank "H," chips and water being eliminated. From the sloughing-off tank, the fine ore flows through the spigots to an eighteen foot Log Washer, "I," where the ore is again washed, concentrates being discharged over the shallow end into the shipping bin, and the overflow, which contains the finer sand and finer ore, goes to a settling tank. The overflow from the sloughing-off tank goes to a similar settling tank, the overflow from both settling tanks "J" and "K" going to waste. The slowly settled slimes in these tanks is discharged through bottom spigots and fed onto Overstrom Tables, of which there are twenty per unit, on which the final concentration is done, the tailings going to waste. The fine concentrates from these tables are elevated by Frenier sand pumps "M" to settling tanks "N," from which the concentrates as settled are drawn off into the shipping bins without excess water. The overflow

from this tank is led to the tank "O" supplying the wash water for the dressing on the tables and thus is prevented from leaving the mill carrying any mineral of value. This small wash water supply tank has its level maintained automatically, fresh water from the supply lines being introduced for this purpose, constant head being thus maintained at the tables.

The ore coming from the mines runs from 35 per cent. to 50 per cent. iron, and is raised to an iron content of from 58 per cent. to 62 per cent. by the treatment in this mill, the final grade depending partly on the furnace requirements. For each unit there is installed a motor equipment totaling 135 horsepower, as follows: For the revolving "D," the two 25 foot Log Washers "F," the two 18 foot Log Washers "I," and the Picking Belt "E," there is provided a 100 horsepower induction motor; for the twenty tables and the Chip Screens, a 15 horsepower induction motor; and for the eight Frenier sand pumps, a 20 horsepower motor. The water supply is pumped through a 30 inch main from Trout Lake $1\frac{1}{4}$ miles distant, into an elevated tank of 100,000 gallons capacity, from which each unit receives its supply at 70 pounds pressure through a 14 inch main. There is provided for each unit a pumping capacity of 1700 gallons per minute when the complete plant is in operation.

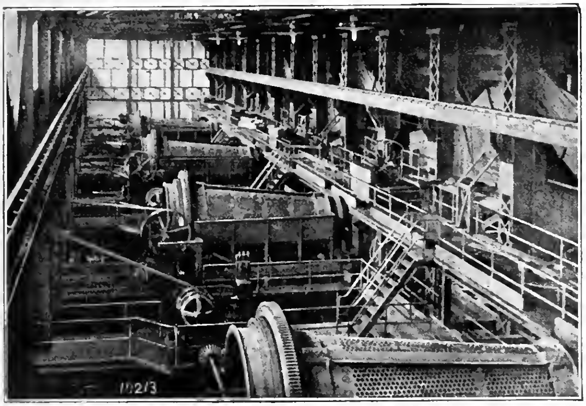



Figure 2.

The success of this plant pointed the way for other mining companies having similar problems, and during the winter of 1911-1912 there was constructed the plant of the Wisconsin Steel Company, built along the lines of the former plant, but with features of its own. It is built at an elevation of some 112 feet above O'Brien Lake, which will allow of a settling basin for the sands rejected by the plant and prevent them flowing into the lake.

This plant consists of a single unit at the present time, but provision is made for increasing the number of units when it becomes desirable. The ore coming from the company's open pit mines, where it is loaded by the steam shovels, is discharged from the cars into a steel bin of some 250 tons capacity. From this bin the ore is fed onto the long inclined conveyor, on which it is carried into the building and discharged onto the short grizzly, with openings at $9\frac{3}{4}$ inch centers. The oversize from the grizzly is rejected into the rock chute if waste, or broken to pass the grizzly if ore. All material passing the grizzly falls along a chute to the small end of the revolving conical trommel where it undergoes washing as well as screening. The oversize from the trommel falls onto a picking belt, from which the waste rock is sorted out, the ore being discharged by the conveyor into ore bin. The undersize from the trommels is divided between the two 25 foot Log Washers.

The mill machinery is driven by a 100 horsepower motor, this including one screen, two 25 foot washers and two 18 foot washers, and the pickling belt. A 30 horsepower motor is used to drive the main conveyor, which is 36 inches wide and 151 feet long; a 20 horsepower slip-ring motor is used to operate the feeders under the ore bins.

The pumping unit in the power plant has a capacity of 2500 gallons per minute against a head of 250 feet, and is carried to the mill through a 16 inch main where it discharges into a storage tank having a capacity of 25,000 gallons. This water is distributed within the mill at 40 pounds pressure.

The principal machinery in both of these plants and in the power plant as well, is the product of Allis-Chalmers Manufacturing Company. In the case of the Oliver Company, the generating unit is an engine driven alternator of 1200 K. W. capacity, supplying power in the mill at 3-phase, 60-cycles, 440-volts. In the case of the Wisconsin Steel Company, the power unit is a steam turbine driven alternator with a capacity of 500 K. W. at 80 per cent. power factor, running at 3600 R. P. M. generating a 3-phase, 60-cycle, 2300-volt current, which is transformed down to 440 volts at the mill.

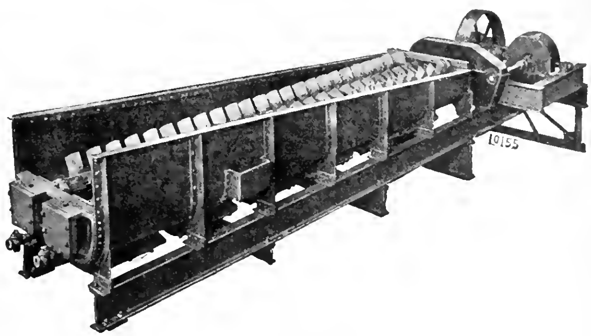



Figure 3.

The successful operation of these two plants is referred to in an article by Mr. Dwight E. Woodbridge, published in the Engineering and Mining Journal of February 8, 1913, from which we quote briefly: "During the past year a sand washery was built by the Wisconsin Steel Company for its Hawkins mine, Mesabi district. It was in use for most of the shipping season and of the 650,000 tons of ore mined all but 150,000 tons were put through it for beneficiation. The mill was planned for a stated capacity of 5,000 tons of

**Don't forget to fill out and return the Pink Slip — See page 32.**

concentrates per day, but has exceeded that figure by 50 per cent. The Hawkins mine contains many millions of tons of sandy ore that can be washed at a high profit. At the great sand washery of the Oliver Iron Mining Company, at Coleraine, Mesabi range, a total of 2,500,000 tons of washed ore has been turned out in the season, and the plant has handled as high as 90,000 tons per week. This plant was built for a capacity of 20,000 tons per day but has run to 50 per cent. overload."

The use of Log Washers is not new, they having been used in the South for removing clay from iron ores, as well as for a number of other purposes in other places, but the older forms were inadequate for present day service on the great iron ranges of the Northwest. Experience in handling large tonnages and a thorough understanding of the principles involved were drawn upon in the design of the log washers described in this bulletin; they contain a number of features developed and patented by Mr. John C. Greenway who has granted the manufacturing rights to this company.

One of these log washers is shown in Fig. 15 and has two shafts carrying paddles mounted in bearings in the end housings of the tank or trough into which the ore is fed. The bottom of the tank and the shafts are equally inclined so that the paddles wing close to the bottom and, the shafts turning in opposite directions, the paddles lift the ore, and being shaped and arranged to have the form of a screw conveyor, the heavier particles of ore are given a forward movement along the incline, and after being washed by the counter-current of water, are pushed over the shallow end into the concentrates bin. Jets of water are introduced into the bottom of the tank which keep the finer particles in suspension, letting the heavier particles settle; the water introduced provides a strong current which carries the light particles in suspension with them and out of the washer over the weirs at the deep end.

Any accumulation of fine ore in the bottom of the trough may be removed through the gates or spigots suitably placed in the bottom.

Allis-Chalmers Manufacturing Company is prepared to furnish the complete equipment of Iron Ore Washing Plants, as well as for other ore treatment plants. Its long experience as a manufacturer of mining, milling and power equipment, and the experience of its engineers with successful plants and field conditions are available to prospective builders of such plants. We invite your inquiries.

# Meeting Re Organization of Iron and Steel Section of Canadian Mining Institute

At the instigation of the Canadian Mining Institute a meeting of the iron, steel, foundry and machine shop interests of Canada was held at the Engineers Club, Montreal, on the evening of February 6th.

Dr. Alfred Stansfield, Professor of Metallurgy at McGill University, and Chairman of the Metallurgical Section of the Canadian Mining Institute, presided.

In opening, Dr. Stansfield explained that the meeting had been called for the purpose of exchanging views on a topic that had been mooted from time to time, and in different parts of Canada, namely, the question of establishing some sort of organization which would ascertain the needs of the iron and steel industry, give expression to them and assist in filling these needs. Such an organization exists in practically every other country that possesses any considerable iron and steel industry. There are many things which require to be done in the interests of the iron and steel industry of this country—things which other industries cannot be expected to initiate nor the governments of the country to anticipate without some movement and direction on the part of the iron and steel industry itself.

If, after the exchange of views and expression of opinions, such as we hope will take place here tonight, such an organization is desirable, a beginning might be made without further delay. Everything has to have a beginning. It takes time and effort to produce such organization as the Iron and Steel Institute of Great Britain and the United States, in which organizations many of the iron and steel men in this country are already members. But there is work to be done for the iron and steel industry in Canada which we cannot expect the institutions of other countries to perform.

**Previous Attempts.**

This is not the first attempt that has been made in this country to bring about such an organization. Some four or five years ago Mr. Geo. C. MacKenzie, now of the Department of Mines, at Ottawa, made a canvass of the industry concerning this matter, but at that time did not receive sufficient encouragement to go further. Mr. Mackenzie will be with us to-night. He is on the way. But his train is late. Last year at the request of interested parties a Metallurgical Section of the Canadian Mining Institute was formed, largely with a view to better serve the interests of the iron and steel industry, and the development of this Section has resulted in the suggestion that the name of the Institute might be changed to the "Mining and Metallurgical Institute of Canada."

About two years ago a local organization was formed in Montreal known as the "Metallurgical Association of Montreal." Monthly meetings of this Association have been held fairly regularly during the autumn and winter of the last two years. At these meetings papers are read and discussed on subjects of special interest to foundry, machine shop and other metal workers. This work has sufficiently justified itself and similar organization in other iron and steel localities throughout Canada might be formed.

**The Ascertained Views of the Industry.**

From the recent canvass that has been made among the iron and steel interests and from the replies to the invitations sent out for this meeting received from those who were unable to be present, would indicate a complete unanimity of opinion as regards the need for such an organization as is proposed. There, however, seems to be some slight difference of opinion regarding the manner of procedure.

Don't forget to fill out and return the Pink Slip — See page 32.

There is a very considerable number in the industry who feel that an extension of the activities of the Metallurgical Section of the Canadian Mining Institute would be sufficient for the time being.

A few are of the opinion that such an organization should be formed as a branch of the Canadian Society of Civil Engineers, which organization has recently changed its name to the "Engineering Society of Canada."

There are also a few in the industry who feel that the organization should be separate and distinct from any existing society or institute and should be organized along lines similar to the Iron and Steel Institutes of Great Britain and United States.

There also are a few in the industry who feel that the best results would accrue from the establishment of a Canadian branch of the Iron and Steel Institute of the United States.

All these views are deserving of very careful consideration. In weighing the pros and cons of each opinion, we should maintain an open mind and not be in too great a hurry to arrive at convictions. Our sole purpose should be to select the method of organization best calculated to produce the maximum benefit to the iron and steel industry of this country.

We have here a great many communications. It will not be necessary to read the letters received from those present, nor will it be necessary to read the replies from those who were not able to find it convenient to be with us this evening, except in cases where some expression concerning the object of our meeting to-night have been given.

In the reply received from Mr. Mark Workman, President of the Dominion Iron and Steel Company, he says: "I regret a previous engagement precludes my acceptance of your cordial invitation, and I have taken the liberty of requesting our Assistant General Sales Manager, Mr. L. V. DeBury, to attend your function in my stead, which I trust will be satisfactory."

Mr. John Irving, General Sales Agent, Nova Scotia Iron and Steel Company, is out of the city to-day and consequently cannot be with us, but he writes: "I quite agree with the suggestion that a special iron and steel section of the Canadian Mining Institute would be a move in the right direction. Therefore, I would be glad to give any support to the undertaking."

Mr. Geo. H. Duggan, of the Dominion Bridge Company, who was also unable to be with us, says: "In a general way the suggestion seems to me excellent and I am sorry I shall not be able to attend your preliminary meeting. Mr. P. R. Miller, Manager, Canadian Vickers Limited, says, "While I am in full sympathy with the need of co-operation, I regret I will not be in town on Wednesday evening and therefore cannot attend the meeting."

**Mr. George A. Irwin**, of the Algoma Steel Corporation.—The matter before the meeting to-night is one to which I have given much thought. I have heard the need for it mentioned on several occasions by men in the iron and steel industry. Only a few days ago it was discussed at an informal meeting of men from the industry who happened to meet at Ottawa. The iron and steel industry in Canada is scattered over great distances and we have little opportunity of getting to know one another and assist in the solution of common problems. The Statistical Department at Ottawa has been doing its best, but with some sort of an organization we could assist in the collection of accurate data as regards resources and development of raw materials, labor, and markets, both domestic and foreign, on which we must depend for the consumption of our output. There is much attention given by each individual company to the performance of work which might very easily be done by a capable secretary of a national organization and thus prevent duplication and effect economy. Such work would justify the support of the industry, and I believe it would have it from the outset.

**Mr. J. J. Harpell**, President of the Industrial and Educational Press, Limited, Publishers of "Iron and Steel of Canada."—My interests in this matter are educational. After graduating from a Canadian university I spent thirteen months in Europe studying industrial and commercial economics, particularly as regards sources of raw material, methods of manufacture and manner of distribution and marketing. These thirteen months were largely spent in visiting the industrial centres of Great Britain and continental countries, and the one definite conviction formed as a result of these investigations and observations was that the industrial and commercial development of Europe was due more to technical organization and technical literature than to any other consideration.

I have had an opportunity of approaching this matter from another point of view. When I left my old home on the farm in the County of Frontenac, I went as an apprentice to a machine shop in the City of Kingston, where I remained for three years. Soon after entering the foundry I began to realize the need for more education than I had and during the second and third winter I attended the classes of an ordinary night school. In these classes there was absolutely nothing which had any bearing upon my work in the foundry, with the result that I was educated away from the industry I had selected as my life work, notwithstanding the fact that I sought this education with the sole object of being able to do my work in the foundry with greater efficiency and satisfaction, which, I may say, was in accordance with the advice received from the older men under whom I was working. Kingston is now a considerable foundry and machine shop centre, but from what little examination I made there a few days ago, the facilities for a young man working in the shops, to improve himself are no better to-day than they were in the early ninties, when I was receiving my initial experience in that industry. There is no technical school; there are no meetings where papers and discussions on foundry and machine shop work could be listened to and there has been little or no effect made to see that up to date literature concerning this industry is to be had in the public library, nor to encourage the men and boys in the foundry to have recourse to it; nor to encourage its introduction into the homes of those who should be interested.

The current of the average boy's life takes its rise at sources which unfortunately are too often considered by the busy man as of no importance. It is very often the attendance at a lecture or the reading of some piece of literature which first arouses in the boy's mind an ambition, to do something, and the more we throw these occasions in the way of the rising generation the larger will be the proportion of our boys and girls who will prepare themselves for some definite lifework and be able to perform it with a maximum of satisfaction to themselves and to their country.

**Don't forget to fill out and return the Pink Slip — See page 32.**

The one thing which impresses the average observer in the industrial towns of Great Britain and other European countries is the number of local and national organizations, mostly of a technical character, the existence of well-filled libraries and the prevalence of technical periodicals and books.

Our provincial and Dominion Governments have already spent considerable time and money in the creation of facilities such as technical schools, but what is needed now more than anything else is some movement that will encourage those to be benefited to attend these schools.

Much of the credit for the establishment of the various mining schools and for the satisfactory manner in which they have been filled with students is undoubtedly due to the activities and influence of the Canadian Mining Institute, one of the oldest technical-industrial organizations on this continent.

The credit for the establishment of the Forest Products Laboratory and for the opening of technical classes in pulp and paper centres must undoubtedly be given to the activities and influence of the Canadian Pulp and Paper Association, which is not more than five years in existence.

Although the Canadian Textile Institute is less than a year old it has already accomplished much in the direction of creating facilities and of encouraging attendance for technical training in the textile industry.

The foundation for the technical work necessary to the workers of our foundries and machine shops is very well laid in the mining schools of the country and in the work which the Canadian Mining Institute has been doing. It requires only to be extended into the various foundry and machine shop centres and to be broadened so as to have a more direct application to the work which the average mechanic and worker is doing. The work which Dr. Stansfield has begun so well in the organization of the Montreal Metallurgical Association, is calculated to give a service in Montreal which every industrial centre throughout Canada should have. If these local units could be linked up in some national organization which would comprehend membership or junior membership of all the progressive forces in the industry, a movement would be started most likely to supply in time the industry with studious and hence capable workers, as well as technically trained specialists.

**Mr. W. A. Jannsen,** Operating Manager, Canadian Steel Foundries, Ltd.—When I received an invitation to attend this meeting I felt that there was some long-headed person behind this proposed movement, but after listening to the manner in which the last speaker had educated himself away from the foundry I feel he has been discovered (Mr. Harpell "I am making an attempt now to get back to it".)

As technical men we have an obligation to Canada of today and Canada of tomorrow. My experience teaches me that this obligation can best be discharged by a combined effort of the whole industry and by a closer co-operation with the producers of the raw materials we are engaged in working up.

Heretofore we have allowed a lot of scrap iron and steel to be shipped out of the country. Furthermore we have not given the co-operation to the producers of iron ore, which would result in the largest development of the iron ore resources of this country, with the result that the

Don't forget to fill out and return **the Pink Slip — See page 32.**

foundries and machine shops are now suffering from a shortage of raw material. This is a very serious problem and serves to emphasize the contention that the foundry and machine shops interests of this country should be associated as closely as possible with those engaged in producing iron ore and coal, as well as the various alloys which are now used so largely in the manufacture of steel, such as nickel, chromium, manganese, cobalt, molybdenum, and a number of other lesser minerals.

**Mr. W. G. Dauncey.** — After referring to the excellent work which was being done by Iron and Steel organizations, in other countries Mr. Dauncey expressed the opinion that there were several very strong reasons why this proposed movement in Canada should keep as close as possible to the Canadian Mining Institute. The Institute is composed entirely of men interested in the production of mine commodities and hence is a primary industry, and it is well that a secondary industry such as Foundry and Machine Shop work should rest firmly and definitely upon a basic industry. Upon numerous occasions he had advocated and emphasized the vital importance of technical education and had been assured by the principals of important organizations that whilst they fully realized this they were at a loss to know how best to accomplish the object.

The formation of an association such as was now under discussion would provide a sure starting point, according to Mr. Dauncey and he strongly advocated the formation of an association devoted entirely to the interests of the Iron and Steel trades, but in close association with the Canadian Mining Institute.

Others spoke or indicated their agreement with the purpose of the meeting as expressed by other speakers, and at the conclusion of the discussion the following resolution was unanimously adopted: —

WHEREAS some definite organization of the Iron and Steel, Foundry and Machine Shop interests of Canada is desirable both in the educational and business interests of the industry,

BE IT THEREFORE RESOLVED that a movement calculated to produce such an organisation be begun at once and that a further meeting of the industry be held in Montreal on March 7th.

BE IT FURTHER RESOLVED that the following, with power to add to their numbers, be a committee to prepare a programme and make other necessary arrangements for above mentioned meeting, and in the meantime to continue discussion and correspondence best calculated to produce the maximum of information and interest.

The committee appointed were as follows:—

Dr. Alfred Stansfield, Montreal.
Mr. Geo. C. Mackenzie, Ottawa.
Mr. Geo. W. Morrow, Hamilton.
Mr. W. C. Franz, Sault Ste. Marie.
Mr. F. H. Crockard, New Glasgow.
Mr. F. H. McDougall, Sydney.
Mr. Geo. W. Watts, Toronto.
Mr. E. Dart, Welland.
Sir Alexander Bertram, Dundas.
Mr. F. P. Jones, Montreal.
Mr. Geo. A. Irwin, Montreal.
Mr. W. G. Dauncey, Montreal.
Mr. W. A. Jannsen, Montreal.
Capt. James Ross, Montreal.
Mr. J. J. Harpell, Montreal.

and a representative man from British Columbia to be suggested by the Hon. H. C. Brewster, Premier of that Province.

## NOTICE OF MEETING.

A meeting of the Montreal Metallurgical Association will be held in the Chemistry Building, McGill University, at 8.15 p.m., on Wednesday, February 13th.

The subject for discussion will be "Defects in Steel Ingots and Forgings," and the discussion will be opened by papers prepared and read by Mr. A. Gordon Spencer and Mr. S. W. Werner.

P.S.—Anyone interested is cordially invited to be present.



Don't forget to fill out and return the Pink Slip — See page 32.

See page 32.

# IRON & STEEL
## OF CANADA

A Monthly Magazine devoted to the Science and Practice of the Iron, Steel, Foundry, Machine and Metal-working Industries, with an up-to-date review of conditions in these and allied industries and trades

ALFRED STANSFIELD, D.Sc., Editor-in-Chief.
W. G. DAUNCEY, M.E., Associate Editor.

The editors cordially invite readers to submit articles of practical interest, which, on publication, will be paid for.

Subscriptions to any address in Canada, the United States and the British Empire, $2.00 yearly. Other countries Postage Extra. Single copies, 25 cents.

Published on the first of each month by
THE INDUSTRIAL AND EDUCATIONAL PRESS, LIMITED.
J. J. Harpell, President and Managing Director.

A. S. Christie, Eastern Manager.
H. W. Thompson, Western Manager.

Montreal Office:
35-45 St. Alexander St.
Telephone, Main 2662.

Toronto Office—
C. P. R. Building, cor. King and Yonge Sts.
Telephone, Adelaide 3310.

Changes for advertisements should be in the Publishers' hands ten days before date of issue.

Vol. I. MONTREAL, MARCH, 1918 No. 2

**Editorial—**

Shipbuilding in Canada .................. 57
The Future of Canadian Shipbuilding and Shipping .................. 59
Fuel for Canada .................. 59
The Use of Titaniferous Iron Ores.......... 60
Practical Papers on the Metallurgy of Iron and Steel .................. 61

Canadian Shipbuilding, by Col. Thomas Cantley 62
The Source of Capable Seamen, by J. J. Harpell. 73
A New Cutting Steel .................. 79
Launching Concrete Boats Bottom Up.......... 80
An Interesting Incident in Canadian Shipbuilding, by Capt. F. W. Wallace .................. 81
Launching of the "Beatrice Castle"............ 81
A British Columbia Yard .................. 82
Heat-Treatment of Chain Cable .................. 82
Baily Automatic Electric Furnaces for Heat Treating Shells .................. 82
Notes from Hamilton .................. 83
The Manitoba Steel & Iron Co., Ltd........... 83
Iron Ores, by W. G. Dauncey.................. 84
Shell Steel Specifications .................. 86
The Manufacture of Crucible Pots for Steel Melting, by Chas. F. Bristol .................. 87
The Fuels of Canada, by B. F. Haanel.......... 90
Iron Oxide in Molding Sand.................. 95
Opportunities for the Establishment of an Iron and Steel Industry in British Columbia, by Robt. T. Hedley .................. 96
Electrolytic Pickling of Steel.................. 99
Advantages of Hydro-Electric Power .......... 99
A New Apprenticeship System .................. 100
The Mathews Gravity Pig Iron Conveyor....... 101
Electric Drying Ovens in a Rod Mill.......... 101
Electric Furnaces in Petrograd .................. 101
Regulation of Air Supply for Blast Furnaces... 102

# EDITORIAL

The first number of "Iron and Steel of Canada" was brought out at short notice and with no opportunity for arranging for correspondents in various iron and steel centres or for the regular contributors who assist so greatly in producing a technical journal. In spite of those handicaps we produced a number, containing 50 pages of letterpress and illustrations, which has been very favourably received by authorities in the Canadian field of Iron and Steel and even in the United States. We reproduce below a few of the congratulations we have received, and take this opportunity of thanking our well wishers and recording our intention to live up to their good opinions of us. Several of our friends have said in effect 'It is all very well to get out one good number but can you keep it up?" "You must have used all your ammunition in the first shot what will you do later?" We are glad to be able to assure our friends that we have some powder and shot remaining; even now we have an abundance of matter in view for succeeding numbers and when we have had time to organize our regular correspondents and contributors we forsee serious difficulties each month in cutting down our matter to fit the available space. We have found an immense mine of rich ore for the Canadian worker in iron and steel; so far we have merely scratched the surface.

---

**Colonel David Carnegie**, writes:—"I am delighted to see the first issue and wish it all success. To bring to the steel makers of Canada a knowledge of the problems waiting solution will be of the greatest help in the development of one of Canada's most important industries."

**Mr. R. N. Hogg, Steel Company of Canada,** writes: —"We wish to compliment you on the get up of the first number of "Iron and Steel of Canada," also, for the valuable information contained therein, and if this issue is a sample of what you expect to put out in the future, I feel satisfied you bid fair to fill the long-felt want for a purely Canadian paper of this description."

**Mr. W. W. Butler, Canadian Car & Foundry Company,** writes:—"It would appear to me to be a very valuable magazine and one which is needed in Canada at this time."

**Mr. T. Linsey Crossley, Toronto,** writes:—"I think that this journal will prove very useful indeed in the Canadian iron and steel industry, and I wish to offer you my felicitations on your work. The publishers are to be highly congratulated on their editorial selection."

**Mr. T. A. Findley, Editor of The Iron Age,** New York, writes:—"The writer has just gone over your first issue, and congratulates you on the excellence of the matter it contains. We wish you success."

**The Canadian Chemical Journal** writes: — The first number which contains 82 pages is most creditable to the publishers, the Industrial and Educational Press, of Montreal, of which Mr. J. J. Harpell is president.

---

## SHIPBUILDING IN CANADA.

From the moment when war was declared in August 1914 it has been axiomatic that the very existence of Great Britain must depend on her supremacy at sea. With a population of 46 millions in an area of 121 thousand square miles, she is obliged to depend to a large extent on foreign countries for the raw materials for her industries as well as for the food for her workers. The population of the British Isles amounts to 380 persons to the square mile and that of England itself to 700 persons to the square mile. In comparison with this we may note that the United States as a whole has a population of 31 persons to the square mile and the New England States, which are rather larger than England and Wales, have a population of 106 per square mile.

With such a population England is obliged to import a large proportion of most of the principal articles of food such as wheat, meat, butter, cheese, sugar, coffee, tea, rice and tobacco, while even milk, eggs and fruit are imported in large quantities. In 1916 Great Britain imported 5 million tons of wheat and half a million tons of flour while her own production (in 1914) was less than 2 million tons, representing about one quarter of the consumption. The imports of food per capita in 1913 amounted to 287 lbs. of wheat and flour, 56 lbs. of beef, bacon, mutton and other meat, 83 lbs. of sugar, 15 lbs. of butter and cheese, 6 lbs. of tea, 15 lbs. of rice and 2 lbs. of tobacco. The value of the principal articles of imported food was over one billion dollars per year before the war and by 1915 it had increased to more than one and a half billion dollars.

Britain is not dependent on foreign countries for food alone, but spends a similar sum yearly for raw materials for her industries. Some two thirds of the iron ore smelted is imported by sea, nearly all the wood and timber, cotton, petroleum and rubber, and

large quantities of wool, jute, flax and hides. The total imports in the United Kingdom in the year 1915-16 were valued at nearly 5 billions of dollars, and every pound of this material was brought across the sea. Britain is also dependent on the sea for fish; before the war 1¼ million tons of fish were caught yearly, valued at 70 million dollars, by a fishing fleet of 370,000 net tons.

Command of the sea was indispensible to Britain, alike for carrying on her industries, which are essential in peace or in war, and for feeding her people. Add to this the increased requirements for the Army in France, and the Navy at sea and the dependence of Great Britain on her mercantile marine is seen to be complete. Before the war British merchant ships of over 1,600 tons had a gross tonnage of 16,800,000 tons. Britain depended on this fleet for her bread and meat, for the iron ore for her blast furnaces and the cotton for her looms.

When, shortly after the commencement of the war, Germany launched her submarine campaign, she aimed a blow at the most vulnerable point in the British Empire, and that attack has been maintained, with varying intensity, for a period of more than three years to the present time. Up to March 1st 1917, the losses, while large, were almost balanced by new construction. At that time the tonnage had sunk to 16,000,000 tons although more than 2 million tons of new ships had been constructed in the meantime. Since that time however the submarines have been more deadly and the net losses during nine months to the 1st January 1918 have been about 2 million tons, corresponding to a total loss of about 3 million tons and a new construction of about one million tons. The war has however hit the importing capacities of Great Britain far more heavily than these figures show; because, of the 16 million tons in March last year, 7 million tons were employed for naval and military purposes, leaving only 9 million tons, or 53% of the original fleet for foreign trade; and if this has been reduced during the last 9 months to 7 million tons, we find that only 42% of the original shipping is now available for importing food and raw materials to England.

The submarine campaign cannot be disregarded; it must be met by the use and construction of war ships and aeroplanes for fighting the submarines, and by the construction of new merchant ships to replace those that are sunk. In regard to the former we have little information, but some figures are available in regard to mercantile ship construction, and the subject is of great importance to us as Canadians. Great Britain is building nearly two million tons yearly of new ships; the United States has begun building and expects to turn out three million tons during the present year; what has been done in Canada?

Canada shares the sea tradition of the British Isles; Canada has a hardy sea-faring population in the Eastern Provinces, Newfoundland and the Pacific Coast; Canada has the iron ore, the coal and the appliances for turning these into ships for the salvation of England and the Empire.

Shipbuilding in Canada has often been advocated but the tonnage of Canadian owned ships and the rate of building new ships has continued to decline during the thirty years preceeding the war. The main reason for this has been that ships could be built in the yards of England and Scotland more cheaply than was possible in Canada. The war has changed all this; now there is an unlimited demand for ships; now the question of cost is a secondary consideration; now the supplies of steel in England are so fully needed at home that she turns to all parts of the world for more steel and more ships. Canada is concerned in this matter not only as a part of the British Empire; not only to carry food and supplies to Canadian soldiers in France; but for the establishment, at this time, of an industry that will increase, in many ways and with compound interest, Canada's position among the nations.

A good beginning has been made. Since March 1917 four steel ships, amounting to 13,900 tons, have been finished, four wooden ships have been launched, and many more are in course of construction. Contracts have been placed by the Imperial Munitions Board during the last twelve months for 43 steel ships, amounting to 211,300 tons and costing $40,000,000, and 46 wooden ships, amounting to 128,000 tons and costing $24,500,000. These contracts represent a total tonnage of 339,300, costing $64,500,000, but it is expected that 400,000 tons of new shipping will be constructed in Canada during 1918. Under these contracts British Columbia receives $31,434,000, Ontario $19,240,000, Quebec $11,600,000, Nova Scotia $1,340,000 and New Brunswick $1,000,000; nearly one half of the contracts being let in British Columbia. Practically every shipbuilding plant in Canada that is equipped for steel ships is building for the Imperial Munitions Board, and the Board takes up each berth as soon as it becomes vacant. As steel plates of the sizes needed for modern ships are not as yet being rolled in Canada, the Department of Marine and Fisheries has made arrangements for securing the necessary steel in the United States.

We print in this issue an article by Col. Thomas Cantley on Canadian Shipbuilding which contains many valuable suggestions with regard to the ways in which Canada can best take advantage of the present situation. The author indicates the need for increased shipping, the present program of shipbuilding in Canada as a shipbuilding and shipowning country, the facilities for shipbuilding in this country and the means whereby Canadian shipbuilding can be established and put on a permanent basis,

## THE FUTURE OF CANADIAN SHIPBUILDING AND SHIPPING.

"Ships, more ships, and still more ships"! is the call of the forces of civilization, in death-grips with the unspeakable Hun — the enemy of everything a freeman considers worth living for. In answering this call — and it is being answered — the balance of ship power is rapidly inclining towards the continent of North America. In carrying out their extensive program of shipbuilding, neither the United States nor Canada are giving much thought to any other consideration than the delivery of vessels as rapidly as possible. But incidentally this effort is creating a shipbuilding industry which should be preserved and fostered in times of peace. Shipbuilding and shipping are assets worth any nation's effort to attain. The former will be created by the demands of war but the latter, and even our retention of the former, will be determined by other considerations.

In times of peace it is not sufficient to be able to build ships. We must also provide the crews to work and navigate them if they are to be retained in our own merchant marine fleet; and if they are being built for a foreign purchaser, the crew must be provided to deliver and operate them out of the port of the buyer, until a native crew has been trained to take them over. This is an advantage Great Britain has had over her rivals in the shipbuilding and shipping business. By reason of her power to man and navigate vessels, Norway, proportionate to her population, has been the best customer of ship builders. Ability to provide capable seamen for her own ships, is also the one consideration more than any other that is giving Japan the ascendency in shipping she is now attaining.

The question of providing capable navigators is now receiving much attention by shipbuilding and shipping interests and for this reason we re-produce from the current issue of the "Canadian Fisherman" a thoughtful contribution to the discussion of this subject. This article appears elsewhere in this issue under the title of "The Sources of Capable Seamen."

In reading this article one is impressed by the conviction that Canada possesses on her Atlantic and Pacific Coasts and in her Great Lakes a source of capable seamen, unsurpassed by any other country.

There is also another thought that bears in upon the reader, namely, the close relation which one industry may bear to another. In this country there has been too great a tendency toward industrial parochialism and even industrial antagonism. The best results are attained by industrial co-operation. If Canada is to take her place among the shipbuilding and shipping countries, it will be as a result of a co-operative effort on the part of her fishing, mining, forestry, agricultural, manufacturing, banking, and professional, particularly engineering, interests. Canada possesses all the latent facilities for shipbuilding and shipping. She had the natural resources of coal and iron, the inherent skill, both for building and navigating. She lies in the closest proximity to the world's greatest oversea markets — that of Europe on the East and of the Orient on the West. In her farms, her mines, her forests and her fisheries, she possesses exceptional resources of marketable commodity, as well as cheap hydro-electric power — a factor of much and ever-growing importance in production and manufacturing.

But in the history of shipbuilding and shipping, as in that of all other industries, there are times when the business requires special attention and support. This is always required in the initial stages. It is also required in times of keen and unprofitable competition. In Great Britain orders were placed for ships when times were bad as well as when they were good. If contracts were slow in going forth the financial institutions assisted builders to construct vessels on their own account. In the words of a recent issue of the Weekly Times Supplement, "Dividends were passed but still orders were placed; so great at times was the surplus of tonnage that schemes were prepared for the laying-up of ships. The result of the shipping policy was that at the outset of war there was the sum of twenty-one million tons of British shipping available. British builders did more than build for British owners. They built largely for Norwegian and other foreign owners; and an immense amount of tonnage was thus provided which, to the great advantage of those owners, and also to the great benefit of this country, has been available during the war."

As already stated, Canada is well provisioned by nature to become an important shipbuilding and shipping country. But the industry will require considerable support from her Government and her people to get under way. Also many adjustments and improvements in the way of insurance regulations, waterways and port facilities will have to be made. To encourage export, banking institutions will be expected to lend their aid, particularly in the way of discounting drafts against bills of lading at rates that will enable the Canadian exporters to finance his shipments as cheaply from Canadian ports as his competitors in the ports of other countries.

(Scarcity of native seamen has always hindered the growth of the American ocean marine. Campaigns are underway now to give special privileges and inducements to young Americans to enter seafaring vocations and man the American marine now building.)

---

## FUEL FOR CANADA.

Most of us have realised painfully, year after year, our dependence on the anthracite coal fields of the United States for the fuel without which we could scarcely exist through a Canadian winter; and in view of recent developments to the south of us we are beginning to feel that we are depending for an absolute necessity on a very insecure foundation.

We have, in Canada, important deposits of coal in the East and in the West, but these deposits are far removed from large areas of central Canada, and even where the distances are not prohibitive the coal is usually unsuitable for use in our domestic furnaces. The true coals, whether bituminous or anthracite, are limited to the extreme east and west of the Dominion, but in between we have enormous deposits of lignites and thousands of square miles of peat bogs which should be developed and made available for domestic and manufacturing purposes.

In the past, these problems have been regarded merely from a profit-making point of view, but in these changed times, we must take a wider view of things; considering first the need of providing a dependable supply of fuel for Canadian consumers at a moderate price and regarding, as of secondary importance, the matter of profits.

The supply of fuel for domestic use in Canada involves the solution of a number of problems. We must, for example, convert our bituminous coals into fuel suited to our domestic furnaces, or we must alter our furnaces to suit the fuel, or as a third alternative we may burn the fuel in central stations, making producer gas which could be used for heating our homes, with an enormous saving in the cartage of coal and ashes, and individual labor in attending to furnaces. Next to this we must solve similar, but more difficult problems in regard to the utilization of the lignite coals of Alberta and Saskatchewan, and after that we must find a solution of the long standing peat problem, so that large areas of Canada that are remote from any form of coal can be supplied conveniently with a fuel for domestic use.

We print in this issue a paper on "The Fuels of Canada," by B. F. Haanel, which was read at the recent annual meeting of the Canadian Society of Civil Engineers. Mr. Haanel enumerates the fuel requirements of Canada for railways, heating and industrial purposes; the fuel resources of Canada, consisting of anthracite, bituminous and lignite coals, and also of peat bogs. He then treats of the preparation of lignite and of peat for economic use, and discusses the production of oil from oil shales, coking ovens and oil wells.

The economic recovery of peat from the bog and its conversion into an effective fuel has been discussed for many years and much money has been spent in attempting to solve the problems which present themselves. Much has been learnt during recent years, and it seems probable that some action will soon be taken to establish a satisfactory peat industry in Canada. The peat situation will form one of the topics for discussion at the annual meeting of the Canadian Mining Institute on the 6th of March, and a paper on this subject will be presented by Mr. Moore, who devoted himself to this work for a number of years and was in charge of the Government plant at Alfred, Ontario.

## THE USE OF TITANIFEROUS IRON ORES.

In view of the enormous deposits of titaniferous iron ores in Canada and the limited supply in this country of ordinary hematite and magnetite ores, any information with respect to the possibility of utilizing titaniferous ores is of great interest. In the Metallurgical and Chemical Engineering for February 1st, 1918, p. 117, appears an article on the "Development of the Metallurgy of Titanium," by Auguste J. Rossi,—a man who has for many years identified himself with this question; so much so, in fact, that 'Titanium' and 'Rossi' are almost equivalent terms. Mr. Rossi, having had experience of smelting titaniferous ores containing some 1½% of the oxide, and finding that this had no effect on the working of the furnace, was naturally much surprised when meeting the prejudice with which titaniferous ores had been regarded. In one scientific paper it was stated:

> "That 1% of $TiO_2$ in a slag was enough to make it pasty to impossibility of tapping and that the slags had to be pulled out with tongs."

In a legal suit with respect to the use of these ores a blast furnace manager testified under oath:

> "That 0.75% of $TiO_2$ in iron ore rendered it unfit for blast furnace purposes, as it would be only a matter of a short time before the furnaces were choked up if the use of the ore were not stopped."

Another blast furnace manager testified that not 0.75% but even 0.25% of $TiO_2$ in an iron ore precluded its use in a blast furnace, it being merely a matter of a little longer time before the furnace would be choked up.

Mr. Eckert testified that:

> "From his twenty years' experience in iron making and blast furnaces not 0.25%, but traces of $TiO_2$ was sufficient to produce the same result as above mentioned."

The above indicates the opinion of the profession at the time when Mr. Rossi began his work. In face of this he was able in 1894, at the New York Car Wheel Works, Buffalo, to smelt without admixture, in a small furnace of three or four tons' daily capacity, titaniferous iron ores from the Adirondacks containing 15-18% of $TiO_2$ and 55-56% metallic iron. The slags analysed 25-30% $TiO_2$ with some 15-18% silica. He used lime, alumina and magnesia as bases in this slag. While Mr. Rossi has undoubtedly shown that ores containing large amounts of titanium can be smelted practically in blast furnaces, it must be recognized that titanium has a certain limiting effect in the metallurgy of iron. Mr. F. E. Bachman recently carried out a very large test in smelting titaniferous ores in one of the large blast furnaces of Weatherbee, Sherman and Company at Port Henry, making in all some 15,000 tons of pig iron. Mr. Bachman, using a titaniferous concentrate containing 55% of iron and 8% of titanium, found that this could be used in admixture with non-titaniferous ores to the extent of ¼th of the charge, which would thus contain about 2% of titanium, without interfering in any way with the operation of the furnace, or causing any increase in the consumption of fuel; but that if larger proportions of the titaniferous ore were used it was not practicable to make foundry iron, although white iron low in silicon could still be made successfully. Apart from this limitation it should be added that the iron made from ores containing titanium is in general better than the iron from non-titaniferous ores and, although this point seems difficult to believe, it appears that the steel made from such iron is also better.

Mr. Rossi also gives an account of his early work beginning about 1900 in the production of ferro titanium near Niagara Falls by reducing titaniferous iron ores in an electric arc furnace. For this purpose he melted highly titaniferous minerals—such as ilmenite—containing 40 per cent $TiO_2$ with carbon and enough scrap iron to dilute the resulting alloy so as

to produce a product with 19-25 per cent of titanium; 15% being found, later, to be the most generally suitable. Ferro titanium is used, as is well known, as a cleaning and deoxidising addition to both iron and steel; titanium having the valuable property of uniting with both oxygen and nitrogen which may be present in the metal, and removing them in the slag. Small quantities of titanium in steel have also special properties which need not now be considered. Titanium is also used as a cleanser for the treatment of copper and other metals. Compounds of titanium have important uses; a violet solution of ferrous titanium chloride has been found to be a valuable bleaching reagent for use with articles of silk and wool which cannot be bleached without injury by means of chlorine. Titanium oxide, prepared by a special method, has been found to be of great use as a paint.

The above extracts and observations merely touch the fringe of the metallurgy of titanium. We hope in some future issue to take this matter up more fully in view of its importance in this country.

## PRACTICAL PAPERS ON THE METALLURGY OF IRON AND STEEL.

With the object of rendering the utmost possible assistance to those engaged in the production of iron and steel it has been arranged to publish an article in each month's issue dealing in a practical way with some one of the essential operations. In this manner the whole subject of the metallurgy of ferrous products will be covered in accordance with the following synopsis: Iron ores, their mining, preparation for smelting, and classification; Blast furnace practice or the production of metallic iron; grades of iron, their physical and chemical characteristics and the purposes for which each kind of iron is suitable. The puddling of pig iron and the production of wrought iron; the conversion of pig into gray and white iron castings, and the malleableizing of the latter by heat treatment and chemical reactions. Steel production by the crucible, Bessemer, acid and basic open hearth methods, and by means of the electric furnace. Special attention will be devoted to the sections dealing with high carbon and alloy steels, and also to their heat treatment. In later articles the fields of the chemist and metallographer will be covered, and the special functions of each discussed in relation to the manufacture of iron and steel. By means of these papers we hope to stimulate the discovery, mining and correct treatment of Canadian iron ores; we shall be able to put into the hands of blast furnace managers the latest details of European practice, and shall endeavor to show that many small deposits of ore, although too limited to justify the expenditure necessary for the erection of blast furnaces, will still pay to exploit in other ways. The developments relating to gray iron castings, cupola practice, foundry sands, machine moulding, etc., will form the subject matter of one or more articles. In visiting foundries in Canada one is often struck with the crude design of cupola, bad arrangement of fan and blast pipes, and haphazard methods of charging and working, and it will be our object to show that a properly designed cupola, rightly proportioned tuyers, and correct pressure and amount of blast will materially increase the product for a given fuel consumption, and will also tend to improve the quality and uniformity of the castings produced. Again, the Canadian practice for the production of white-iron castings for malleableizing is costly and erratic, and one article will be devoted to this section of metallurgy. We hope to be able to show how our furnace practice may be improved; how mis-run, cracked and faulty castings may be reduced, and how money may be saved on annealing costs. Had the black-heart malleable manufacturer realized the importance of improving the standard of his product, much of the work now placed with the steel founder would have remained in the hands of the malleable iron maker. We shall show that steel and malleable iron are each for certain purposes better than the other, and shall indicate clearly the purposes for which each should be used. To accomplish this object it is not necessary to antagonize the maker of either, for if it can be shown that each metal possesses characteristics that render it peculiarly suitable for certain purposes then the result will be mutually advantageous. In the realm of steel making the whole question of furnace design, fuel, and variations of stock charged will come under review, and we shall endeavour to demonstrate that, notwithstanding the enormous improvements of the last three years, there yet remains much to be done, both as regards furnace and foundry practice, if the highest grade of steel is to be produced at a minimum cost.

Another section of the utmost importance will be that devoted to the production of tool steels, high speed steels, and special alloy steels, and in this field the necessity for correct practice is of more importance than in any other connected with steel production. It is probable that in the near future we shall see most of this class of steel made in electric furnaces, and in that case the works will be located where power is cheap and plentiful. Looking at after-war conditions, we see a new and intensive form of competition to be met, and in our opinion the only way to meet this is by studying closely all the operations incidental to iron and steel manufacture, with the objects of eliminating any unnecessary expense, of shortening any operation wherever possible, and of increasing both the quantity and the quality of the product. To aid in such desirable results we have arranged for this series of articles to be written by Mr. W. G. Dauncey, who is experienced in the production of iron and steel under varying conditions, and in many countries. In conjunction with this series of articles we hope to inaugurate a correspondence column and shall endeavour to make it a special feature, believing that the average foundryman and steel maker often requires information which he has neither time nor facilities for acquiring, but which we can supply at his request. Briefly and in outline only we have indicated the nature and object of these articles and it will be the endeavour of those concerned to supply information that may be reliable, up-to-date and of assistance to all those engaged in the practical operations incidental to the manufacture of iron and steel in Canada. Having the utmost faith in the future of this industry, and believing that a journal exclusively devoted to its interests can be of the greatest possible assistance, we shall not be guilty of sparing any efforts to be of use to both technical and non-technical men. The educational value of comprehensive practical information cannot be over-estimated, and we hope to make this journal one of the most potent factors in the development and expansion of the Canadian iron and steel industry. The first of this series of connected articles appears elsewhere in this issue.

# Canadian Shipbuilding

By COL. THOMAS CANTLEY.

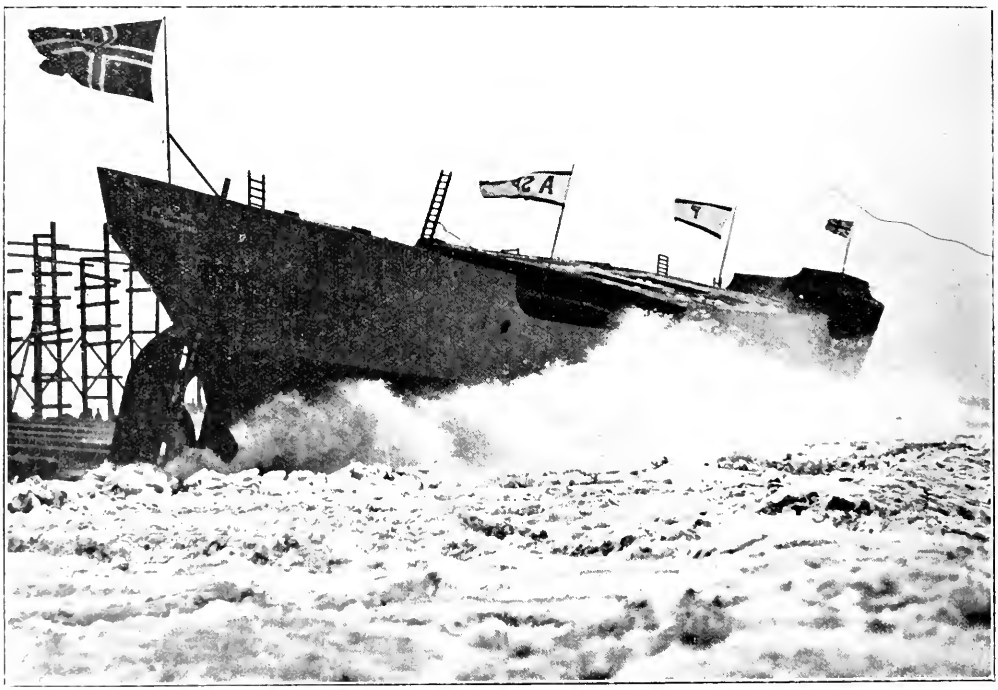
(This paper will be presented for discussion at the Annual Meeting of the Canadian Mining Institute in Montreal on March 7th.)

The question of developing steel shipbuilding in Canada on a large scale, and making it a more permanent industry than at present, is a matter of national importance. The matter is of vital interest from the viewpoint of supplementing the sea transport facilities of the Empire, and our Allies now and during the further progress of the war, and, secondly, as regards Canadian overseas traffic after the war.

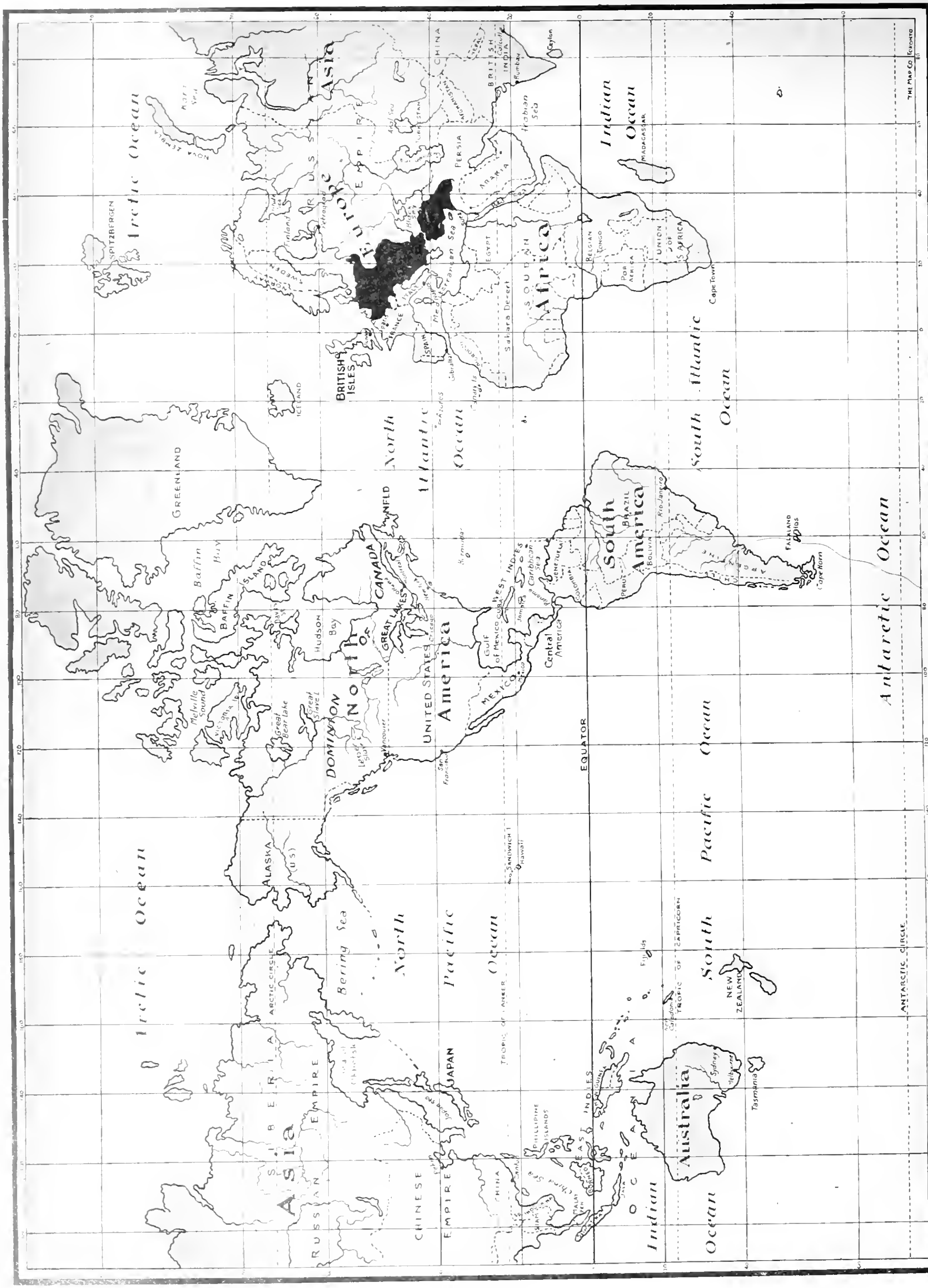
The daily press has not failed to remind us of the tremendous shortage of shipping tonnage, of the heavy toll exacted by the enemy submarines, and all of us who are conversant with trans-Atlantic shipping as now carried on, must realize the delay and loss of time incidental to the convoy system, which is assumed to be unavoidable if our present practice in that connection is continued.

The shortage of shipping tonnage, already serious at the commencement of 1917, became more acute with the progress of the year, and the intensification of the submarine campaign. Month by month it became more evident that to maintain the continued overseas supply of food, requisite for the Allied Armies and population, the building of ships must be accelerated in every possible way. Indeed ships have now become one of the great essentials of victory! The matter of the endurance of Britain, France, and Italy is mainly, if not entirely, a question of steamer tonnage, and the lack of it may well bring about defeat, or an inconclusive peace.

The daily press and technical journals have from time to time dwelt on the losses through submarine activity, and enemy mines, and unofficially it has been stated that Great Britain, the United States, Japan, and the other Allies have produced in the vicinity of 3,000,000 tons of new shipping in 1917, which is stated to be little more than one half the wastage from enemy activities. With the entry of the United States into the war theatres of Europe, increased demands have been made for ocean transport, and as the armies of the Allies are increased in numbers,



This is a photograph of the "Asp," as it was being launched from the yards of the Polson Iron Works, Toronto, on February 11th, 1918. At this time the ice was thicker than for many years. But a few sticks of dynamite opened a birth for the new boat. Length 261 feet; capacity 3,500 tons.




The above map illustrates the article, "Sources of Capable Seamen" which appears elsewhere in this issue. The location of the principal Fishing Grounds of the world is indicated by the white areas.

"It is not generally known that the important fishing grounds of the world are only four in number, and that all four lie in the northern hemisphere, mainly north of the 40th parallel of latitude."

and the working population of the Allied countries monthly become to a greater extent engaged in the war, the demand for overseas food, munitions, and the raw material entering into every class of supplies required by the armies in the field must continue to increase.

The acute shortage in certain articles of food in Great Britain to-day is not caused primarily by a world shortage of these, but is due primarily and essentially to a shortage of sea transport. The shortage of foreign cereals, cattle, and meats in Great Britain will continue until such time as new steamship construction not only equals but largely exceeds both the ordinary marine and war losses. An increase in the new tonnage to be launched both by Great Britain and the United States is expected during the present year.

Laying the keel of a new ship.

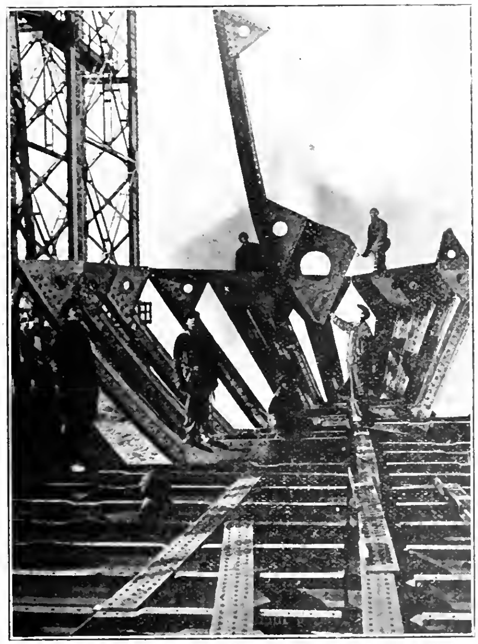
The increase in tonnage from British yards during 1918 will probably be greater than most of us anticipate, while that from American yards will probably be very much less than has been foreshadowed for many months by the press of that country.

So far as Canada is concerned, while we are doing something, the total tonnage actually launched during the past year, or that will be put into actual service during 1918 is small. A recent statement indicates that up to December 1917, the British Government had ordered in Canada 44 steel vessels, of which four had then been delivered. These vessels will have a total aggregate capacity of practically 200,000 tons, but in addition there had been ordered by the British authorities wooden steamers aggregating slightly over 100,000 tons. The bulk of these latter vessels, will be built on the Pacific Coast. This total tonnage, both steel and wood, only amounts to 300,000 to 325,000 tons. Further ocean going tonnage has been contracted for subsequently by the Dominion Government, and the total output of seagoing freighters from Canadian yards during 1918 may reach 400,000 tons, although this is somewhat doubtful. So much for our contribution during the present year to the vital problem of sea transport for the Empire and Allies.

What position will the Dominion of Canada occupy in shipping matters at the close of the war? Canada's record as a shipbuilding nation is one of early expansion and subsequent decline. A generation ago, or to be exact, 34 years ago, in 1884, Canadian tonnage stood at its high water-mark—the Registry Books of the Dominion in that year recorded a total of 1,253,757 tons. The years following showed a steady decline, and in 1903, only 652,613 tons were registered as owned in Canada—or a decrease of almost 50 per cent in eighteen years. From 1902 there was a slow but fairly steady yearly increase, and at the end of 1916, the total tonnage registered in Canada was 942,598 net tons, or 25 per cent less than the high water mark of 1884.

The tonnage of vessels actually built in Canada has shown an even greater decline—190,758 tons being built in Canadian yards in 1874 as against a total of only 43,345 tons in 1914. This is surely not a record of which Canadians may in any way be proud.

We have had in Canada, for a number of years past, yards building steel vessels; but these were practically all on fresh water, and none were on the Atlantic or Pacific seaboard. The people operating these yards exhibited considerable enterprise, although they received no encouragement. It is largely due to them



Ocean carrier takes shape as the steel girders are rivetted into place.

that we can turn out a couple of hundred thousand tons of modern steam freighters in Canada this year.

During the past year the Canadian shipbuilding facilities on the Great Lakes have been added to by the establishment of steel shipbuilding plants at Montreal, Quebec, New Glasgow, and to a very considerable extent on the Pacific Coast.

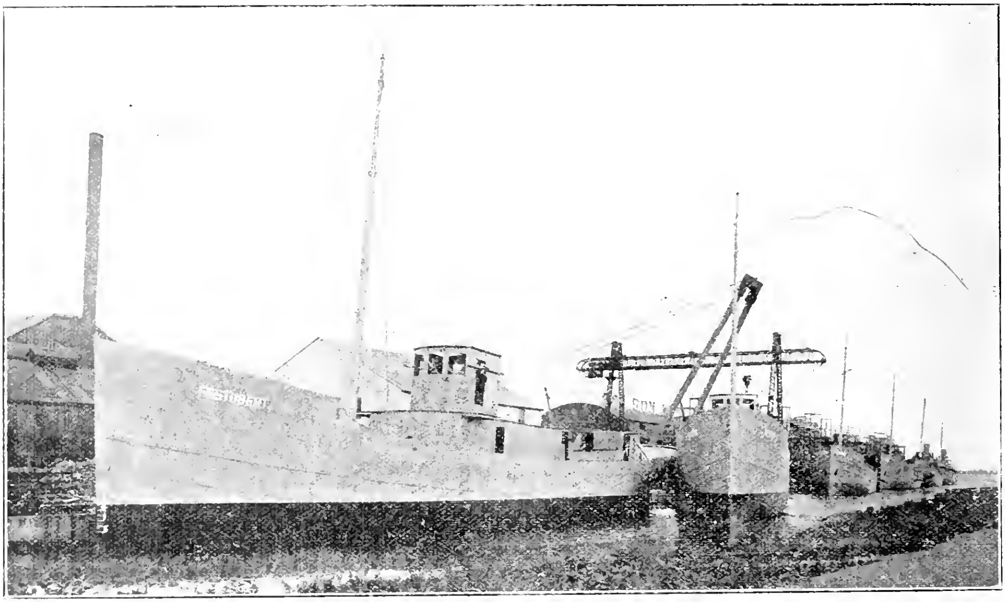
The outstanding factor which brought about the decline of shipbuilding in Canada over the period of thirty years just reviewed, was that the wooden ships were unable to compete with the larger, abler and

more efficient steel vessels, which moved merchandise more rapidly, commanded higher rates of freight, and secured lower rates of insurance on the cargoes carried.

### Canada's Natural Facilities.

Canada is marked out by Nature as a great transportation and agricultural country. Her land surface is divided into great producing areas. The movement of natural products in Canada is on a large scale. Nature devised for her a wonderful system of waterways, with a long indented coast line, supplied with splendid harbors, and a chain of lakes and rivers penetrating from the East 2,500 miles inland, almost to the wheat fields of the Prairies.

The Dominion, in a general way, has been very successful in developing her land transportation system.



INTERESTING SHIPBUILDING OPERATIONS IN PROGRESS AT TORONTO SHIPYARDS.

Ten vessels of the most modern type are under construction at the Pouson Iron Works, Toronto. They are being built for fishery protection and work on them is being rushed. Six of the ten have already been launched and some of these are well advanced towards completion. The vessels are named after familiar places in the story of the Canadian Army at the front, these six being, Festubert, St. Eloi, St. Julien, Vimy, Ypres and Messines. Their length is 140 feet, and breadth 23 feet, depth and mould 18 feet, 6 inches.

On the other hand comparatively little has been done to take advantage of her great system of water transport, and her transportation development as a whole has been poorly balanced. On the Great Lakes, Canadian-owned tonnage is comparatively small. On salt water, Canadian ships carry less than one-tenth of the produce sent out of Canadian ports, while very large quantities of Canadian products pass through American ports, and are carried overseas in foreign bottoms. It is estimated that before the war Canadians were paying over $50,000,000 yearly in ocean freights, of which about eighty per cent went to overseas shipowners. It is by no means improbable that in 1917, over $200,000,000 was paid by Canadians for ocean freight — and again the great bulk of this money passed into foreign hands.

### World Tonnage.

It may be assumed that in the five year period preceding the war the world's production of overseas tonnage averaged about 1,750,000 tons annually, of which Great Britain produced about 60 per cent., Germany 12 per cent., United States 9 per cent., and France 9 per cent., while all other countries produced say 14 per cent. The normal world's tonnage in 1914 was roughly 48,000,000 tons, of which about 6,000,000 tons has been lost, and probably 2,000,000 tons is inoperative through internment, unrepaired damage, etc. Probably not less than 15,000,000 tons have been commandeered by the Allies, leaving available for the various shipowners, more or less free of Governmental control, say 25,000,000 tons—or but little more than one half the free pre-war tonnage devoted to the world's business. These figures explain very easily the present high freights, and the consequent high prices that are now paid for steam tonnage.

Should the war be concluded successfully by the end of the present year, it is doubtful if the steel tonnage then afloat in all the world's ports will exceed 40,000,000 tons, or twenty per cent less than that actively employed in 1914.

Five outstanding facts must be considered:

First.—The great amount of shipping destroyed as a consequence of the war.

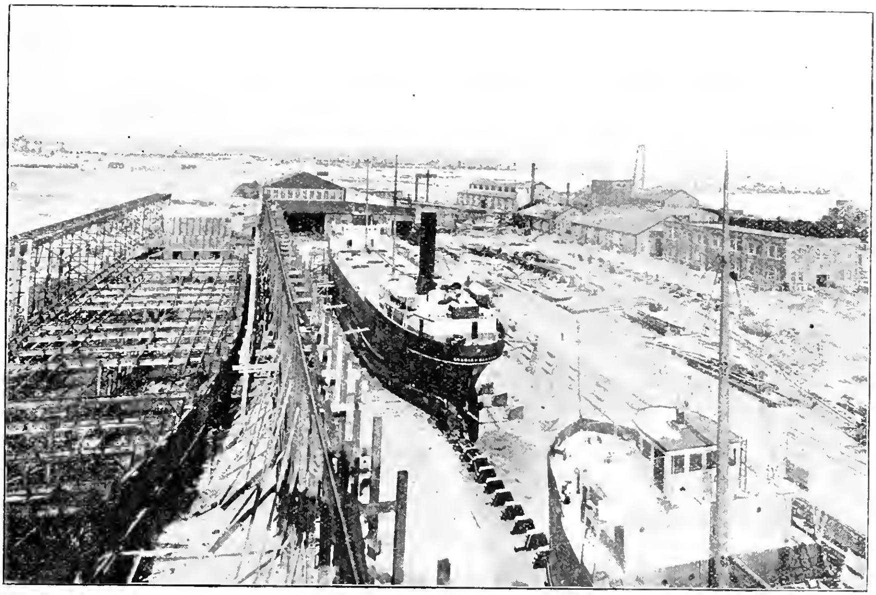
Second.—The greatly decreased production of new tonnage during the past three years.

Third.—The great difficulty which British builders will face in their effort to increase the output of merchant tonnage during the present year.

Fourth.—The uncertainty as to whether the increased shipbuilding program of the Allies for the present year will equal the war and marine losses in 1918.

Fifth.—During the period of the war it has been impossible to replace more than half the tonnage destroyed, and no provision has been made for the growing tonnage demand of the world, which for a score of years will increase at the rate of about ten per cent. per annum.

From the foregoing facts it would appear that, for a number of years a world shortage of shipping is inevitable. To meet the situation the United States have taken up the question of shipbuilding on a large scale. At the beginning of the present year, it was reported that nearly 1,400 vessels, aggregating over 8,500,000 tons, were under construction, or projected for construction during the present year. This tonnage consists of both steel and wooden ships. The latter, so far as they are steam propelled, will probably be a great disappointment, and will add little to the overseas carrying capacity. While the large amount of 8,500,000 tons has been projected for the present year, no one who knows anything about the actual conditions believes that the United States can or will actually put into service during 1918 one half of this tonnage.



SHIPBUILDING PLANT AT PORT ARTHUR.

## Canada's Present Position.

The present shortage of shipping and of ocean transport presents both Canada's difficulty and her opportunity. Every bushel of wheat, every sack of flour, every pound of animal products, and every case of manufactured goods sent overseas, must, owing to the world's shortage of shipping, pay an increased freight toll. Nor is this increase a small one, in many cases there has been a very large increase over pre-war rates, and these high freight rates are a direct tax on all enterprise and production, as they must be met before anything is left for either industry or capital.

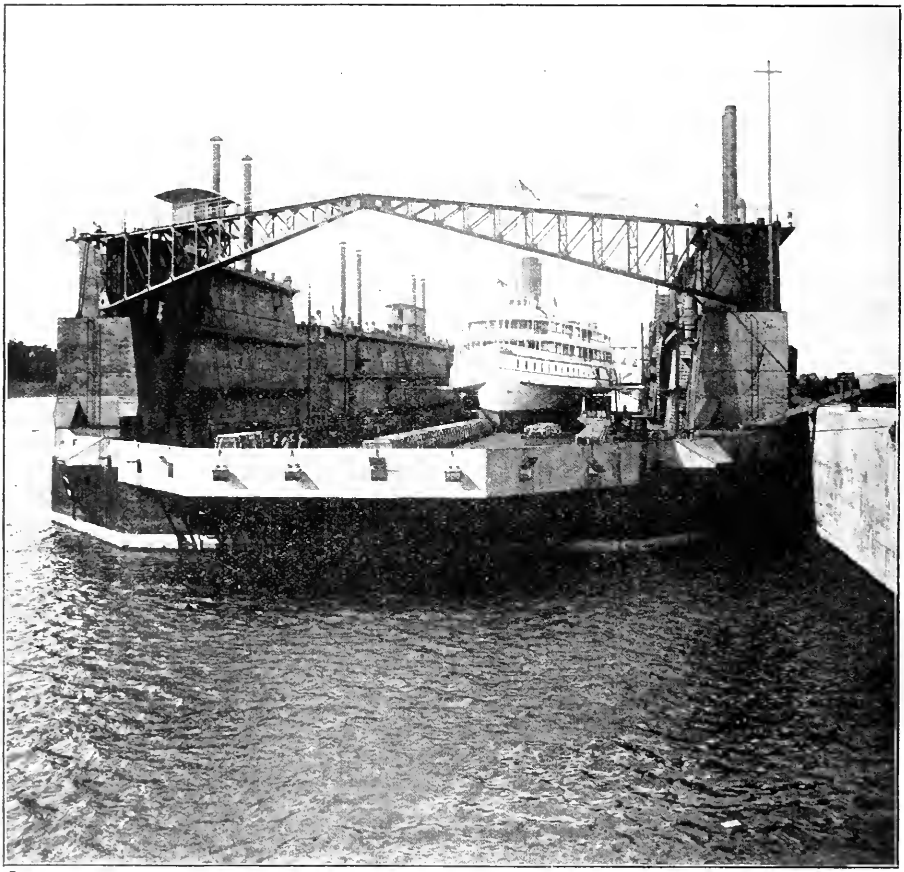
How can we take advantage of the situation, and what are the difficulties in the path of our doing so? At present steel steamers of moderate size can be built profitably almost anywhere in Canada where they can be floated. On the fresh water section of the Dominion west of Montreal, the size of ships which can be gotten to sea is restricted to about 250 feet in length, but on the Atlantic and Pacific seaboard there is no limit as to size. Owing to the abnormally high prices which are being paid for ships, due to the high rates of freight prevailing, it is suggested from various quarters that the industry should now be self-supporting, and that it is so at present cannot be refuted. Present conditions, however, are abnormal and cannot continue. Many of the yards now attempting to build steamships are but makeshift affairs, and when the present shipbuilding boom has passed, they will be unable, on account of their situation or equipment, to compete with established and well equipped builders.

Quite apart, however, from such yards, with the return to normal conditions, even the well placed, suitably equipped and efficiently managed Canadian yards will not easily be able to compete successfully with the highly specialized plants of Great Britain and other marine nations, where the industry has been established for a long time, and has had the mantle of protection thrown about it under various guises.

**British Practice.**

The disadvantages under which Canadian shipbuilders will labor are many. Previous to the outbreak of war Canadian workmen in the shipbuilding trades were paid a wage which was in some cases nearly seventy per cent. in excess of those paid in British Yards. Another important factor is the advantage possessed by the British shipbuilders in the great specialization of industry in the United Kingdom. Few British yards turn out ships complete, or need to lay down the complete equipment for doing so. When the ordinary British shipbuilder secures a contract for a steamer he at once proceeds to sub-contract a large amount of the work. He may himself supply the engines and boilers, or may obtain them from others, but the auxiliary machinery, such as steering gears, condenser, evaporators, circulating pumps, etc., are supplied by various shops which specialize in these particular items. Other firms supply anchors, chains, winches, boat davits, special castings, and other parts, and often all that the shipbuilder does is to construct the hull and assemble and fit into it the engines, auxiliary machinery, and other fittings.

As compared with that practice, and the economies flowing from it, Canadian yards, in the past, had to do all or nearly all the work themselves; but in the future the greater volume of business in Canada will help forward this specialization which is desirable in the interest of the industry, and will tend also to develop numerous specialized industries, and to increase natural resources. Engineers, and boilermakers, machinists, shipwrights and carpenters, brass workers, and plumbers, fitters, platers and riveters, will all greatly benefit by the development of such an industry, and a score of subsidiary trades will grow up around shipbuilding and engineering and will be largely dependent on them for prosperity.



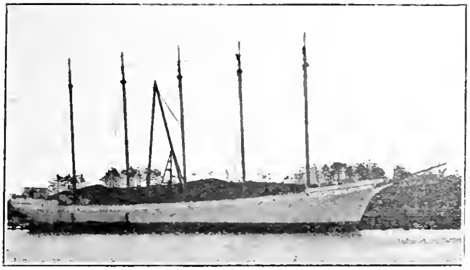
FLOATING DRY DOCK AT MONTREAL.

**Suggested Assistance.**

We believe that the construction in the Dominion of steel vessels, either steam or sail, from Canadian materials, can be accomplished, and the industry can be put on a permanent basis. At first the shops should be built largely from Canadian materials, and within a limited period, say two years, they should be constructed entirely of materials which are wholly the product of Canadian workshops.

First, by the Government of Canada giving such inducements as will result in the laying down of mills capable of producing the sizes of ship and boiler plate that are called for in modern steamship work.

Second, by the payment of a bonus of say ten dollars per ton deadweight, calculated on Lloyd's summer freeboard, on all sail or steam vessels, and in the case of steamers of a further bounty of $2.50 per indicated horse power of the propelling machinery — provided such machinery, that is the propelling engines and the boilers, are the product of Canadian workshops.



The first of a fleet of standard wooden vessels being built at Victoria, B.C.

It is our opinion that the bounty period should not be less than ten years, and that fifteen years may be necessary; but the period for which the bounty is to apply should be clearly stated, and embodied in the Act, so that the prospective shipbuilders would know for a certainty just what bounty payments could be depended upon, and what expenditure they were warranted in making on each plant.

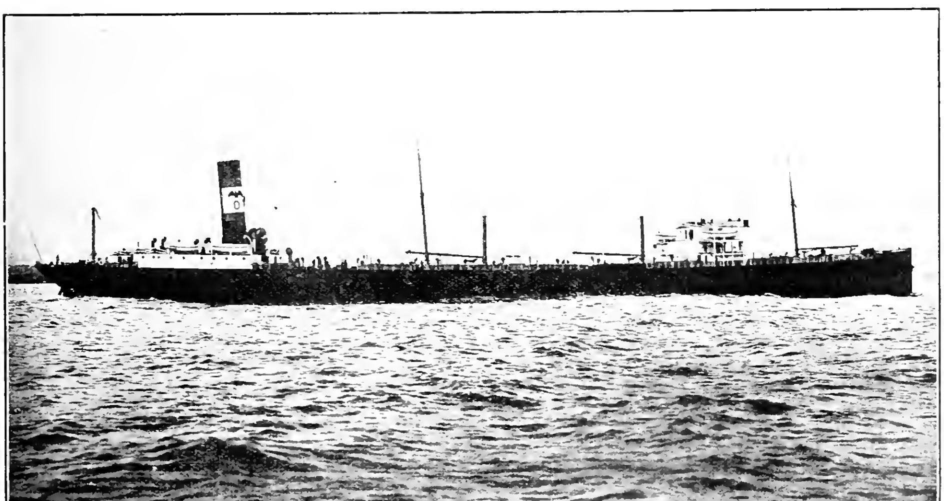
With the Canadian Iron and Steel industry in its present high stage of development, practically the only material now requisite for the construction of steam tonnage, which cannot now be produced by Canadian mills and forges, are the steel plates for the hull plating and boilers. An enterprising Canadian, eminent in the inland shipping trade, has recently intimated that no steel plates are made in the Dominion. The fact is, however, that for nearly a score of years Canada's pioneer Steel Company has been rolling steel plates, 48 to 50 inches wide, from one-eighth to three-quarters of an inch thick, and in moderate lengths of say sixteen feet, and have actually made and shipped thousands of tons of such plates from their mills at New Glasgow. To meet the modern requirements of shipbuilders, however, steel plates are needed both wider and longer than those hitherto produced in Canada.

The Union Government have had this matter under consideration for some weeks, and it may be that some official policy will be announced ere long. Until such time as Canadian plates are available, shipbuilders who have or are compelled to use foreign steel plates should not thereby be debarred from the shipbuilding bounty. The foregoing proposal is one that should become operative after the war, or as soon as the present abnormal conditions cease to exist.

### Steam Trawling.

Let us consider the present situation of our Fisheries. Off the Atlantic Coast of Canada are the greatest fishing grounds in the world. These waters were visited for years before any permanent settlement was made on our shores. The fishing grounds off the shores of Nova Scotia and Newfoundland are for practical purposes, for the present at least, inexhaustible. It is stated that 30,000 men are employed in the deep-sea fishing in Nova Scotia waters alone.

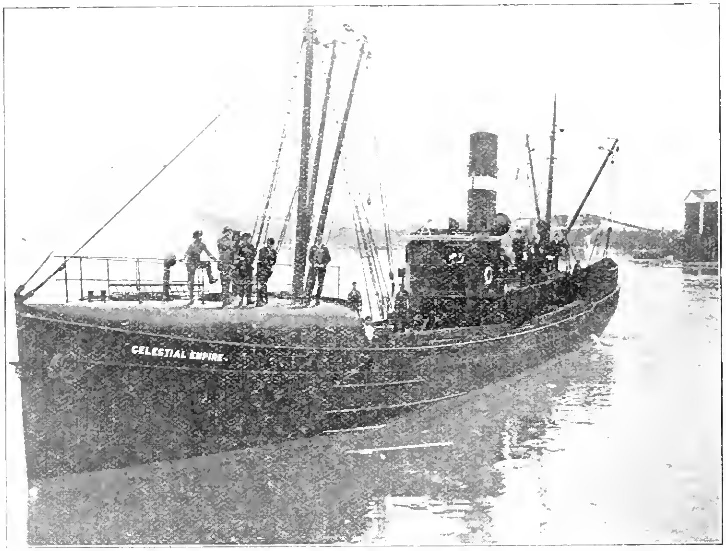
What are the methods under which these men are employed? For the most part they are of the past. There are less than one-half dozen modern trawlers operating, where we have the men, the fishing grounds, and the opportunity to employ profitably five score steam trawlers, and a score of the faster fish carriers and supply vessels. Our Atlantic fisheries, in the past, have been operated much on the scale of the spinning wheel, the hand loom, the hand sickle, and the whipsaw,



A GREAT LAKE FREIGHTER

all of which have been discarded a generation ago. France, for several years previous to the great war, sent out to our waters a fleet of modern steam trawlers, from 125 to 165 feet keel, most of which were of the larger dimensions. Their operations in our off-shore waters were so successful that each succeeding year brought increased numbers and larger vessels. Our people in a general way condemned them, and made ineffectual protests against their operation on this side of the Atlantic. Only two or three of our most progressive firms profited by the object lesson shown us.

No class of steam vessels has been so thoroughly standardized as the steam trawler. Builders on the Clyde launch hundreds of them identical in size, construction and equipment. This is a class of steel vessel which could be built in any of our own yards or ports, and operated from our Atlantic home ports with great advantage to our fishing interests, and which would help materially to increase the food supply of the nation. Canada needs trawlers, and all the material necessary to construct them is produced to-day in our own country. Why not build and operate them?



A STEAM TRAWLER.

### Mercantile Marine.

Assistance will be necessary for the successful operation of a Canadian mercantile service. No nation has ever developed a strong merchant fleet in recent years without governmental assistance. The British Government, for example, set the pace in governmental support when in 1834 it invoked a new form of mercantile marine encouragement. In 1834 a subsidy of \$85,000 a year was given to a British steamship Company plying steam packets to Rotterdam and Hamburg, and another subsidy of \$150,000 to a packet service to Gibraltar. This form of assistance was found to be so valuable in its influence on the then new art of steamship and engine building in the United Kingdom that in 1838 the British Government offered a large subsidy for a steamship service across the North Atlantic. In 1839 Samuel Cunard secured a subsidy of \$425,000 a year for a steam line from Liverpool to Halifax and Boston. This, it is understood, amounted to about 25 per cent. of the cost of running the Cunard line, and was given with the plain intention of establishing firmly in English hands the trans-Atlantic traffic. Other British shipping firms secured subsidies for lines to South America and to the East Indies, and in a few years British subsidies totalled from three to four million dollars annually.

### American Subsidies.

For a time the American Government met British subsidy by subsidy. As an offset to the Cunard subsidized line, the American Government in 1847 concluded an agreement with the Collins line of trans-Atlantic steamers for a subsidy of \$385,000 a year. When, later, the Collins Company built steamships larger than the Cunard ships this subsidy was increased to \$858,000 a year—the Cunard Company at the same time receiving \$856,000 annually from the British Government. Under the impulse of these mail subsidies, American ocean steam shipping rose from 16,058 tons in 1848 to 115,045 tons in 1855.

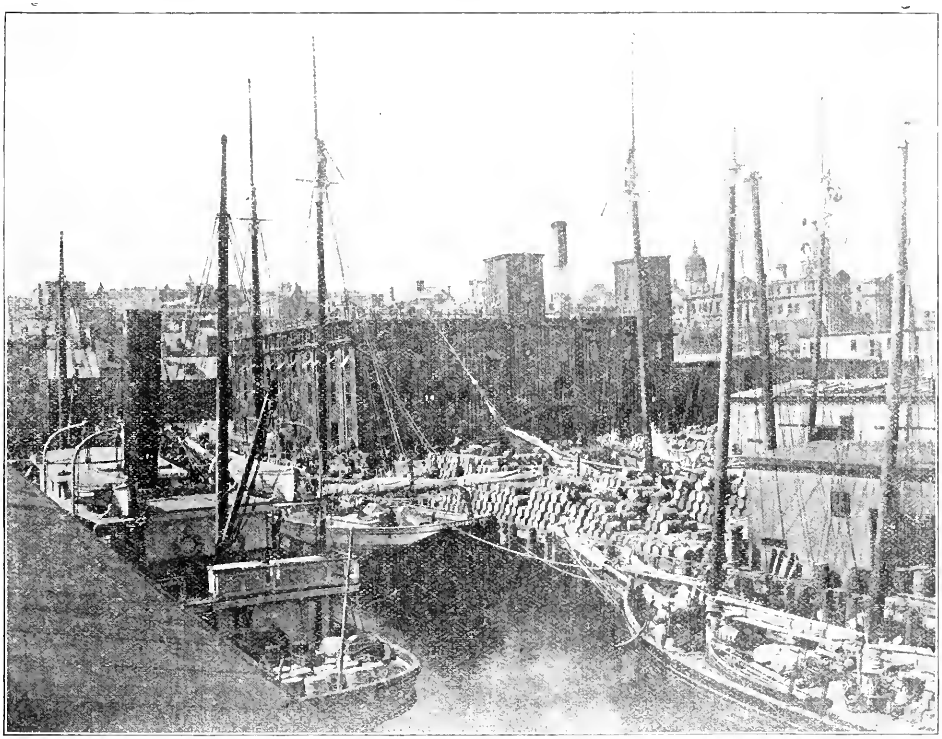
### Decline of American Shipping.

Unfortunately for the American shipowners this beneficial policy on the part of the American Government was not continued. It has often been asserted that the decline in American ocean shipping began with the Civil War in 1861. This, however, is a very superficial view, as the Civil War was only an incident in the decline, which had started six years earlier. Shipbuilding in the United States fell from 583,450 in 1855 to 156,602 tons in 1859; the causes of the decline being in part economic, but to a larger extent political. In 1856 the American Government reduced the Collins mail subsidy from \$858,000 to \$385,000 at a time when the Cunard line were receiving \$856,000. In spite of this drastic reduction the Collins line continued in the service, but the British competition was too keen, and

at last they were forced to quit the field. It may be noted that in 1860-61, when the American Government were withdrawing assistance from their shipping, Great Britain was expending $4,537,223 for the encouragement of steamship building and mail communication with all parts of the world. France, following the British example, offered in 1858 subsidies of $620,000 a year for a line from Havre to New York, and further large amounts for other lines. About the same time, Germany began to subsidize the North German Lloyd, on the routes from which American merchant ships had disappeared.

For a short time after the Civil War, American ocean shipping actually increased, the registered tonnage in 1867 being 1,515,648 tons, and it remained at about the same figures for a decade thereafter, but in this same period the proportion of American imports and exports, carried in American vessels, steadily decreased from 33 to 26 per cent. In 1898 the registered tonnage had fallen to 726,213 tons, or less than half of what it was 31 years previous, and the proportionate carrying to eight per cent. From 1898 there was a gradual yearly increase, and in 1914, at the outbreak of the Great War, this tonnage totalled 1,066,288 tons, but was still carrying only about eight per cent. of the American imports and exports.

In 1891 the American Congress passed the Ocean Mail Act providing subsidies for postal lines, and while the subsidies paid under this Act have not been large, totalling in 1914, $1,089,360, of which $673,998 was received by the American trans-Atlantic service, this aid has proven to be of substantial value to the American trans-Atlantic service.



A SECTION OF HALIFAX HARBOR INDICATIVE OF MARINE ACTIVITY.

### Foreign Subsidies.

In the fiscal year 1914, the United States paid in subsidies to American steamers under contract the sum of $1,089,361. The following table gives a summary of the amounts paid by way of subsidies, mail pay, bounties and by other means to the mercantile marine of the European nations. These figures are for 1909, and are the latest official enumeration by the American Commissioner of Navigation.

| | |
|---|---|
| Great Britain and Overseas Dominions.... | $ 9,689,384 |
| France | 13,423,737 |
| Japan | 5,413,700 |
| Italy | 3,872,917 |
| Spain | 3,150,021 |
| Austria-Hungary | 2,984,530 |
| Germany | 2,301,029 |
| Russia | 1,878,328 |
| Norway | 1,012,143 |
| Netherlands | 880,011 |
| Sweden | 277,752 |
| Denmark | 145,000 |
| Belgium | 55,970 |
| Portugal | 50,000 |

Germany, in addition to subsidies, granted preferential rates on her State Railways for cargoes to be carried in German ships.

Largely as a result of the special aid given this industry by the different Maritime nations, the growth of the various merchant fleets has been remarkable; the following table illustrates this growth during the last decade:

**Recorded in Lloyd's Register for 1895 and 1915.**

| | 1895—tons. | 1915—tons. |
|---|---|---|
| Great Britain | 13,242,639 | 21,045,049 |
| United States | 2,164,753 | 5,368,194 |
| Austria | 304,970 | 1,055,819 |
| Denmark | 356,714 | 820,191 |
| Holland | 446,861 | 1,496,455 |
| France | 1,094,752 | 2,319,438 |
| Germany | 1,886,812 | 5,459,296 |
| Italy | 778,941 | 1,608,396 |
| Japan | 301,101 | 1,708,386 |
| Norway | 1,659,012 | 2,504,722 |
| Russia | 487,681 | 1,053,818 |
| Spain | 554,238 | 898,823 |
| Sweden | 497,877 | 1,118,086 |

Let us look more closely at what has been the policy of the astute Japanese. The courage manifested by Japan in the creation of a national trading fleet has been wonderfully successful, and has placed that nation in the forefront of the maritime powers. Indeed she now ranks as sixth in the list of ship owning countries of the world, having added 425,000 tons to her mercantile fleet during the three year period of 1914, 1915, and 1916. The figures for 1917 are not yet available, but it is not improbable that last year 300,000 tons were added to her tonnage, and this was built entirely in her own yards.

The great development of the Japanese mercantile marine is shown effectively by the following facts. In the year 1905, goods to the value of £4,380,000 were exported from that country in Japanese bottoms, and during the same year the exports in British vessels from Japan totalled £12,945,000, and those of all other nations £14,465,000. Ten years later, however, in 1915, the exports in Japanese bottoms had a value of £48,865,000; in British steamers, £9,217,000, and in vessels of all other nations, £11,381,000. These figures show that while the cargoes carried by British ships decreased in the ten years over 30 per cent., and exports by steamers of all other nations by about 30 per cent., the value of goods carried under the national flag of Japan had increased near 1200 per cent. The steamship tonnage entering Japanese ports from foreign countries in 1905 totalled 1,771,600 tons — the number of vessels being 2,400. In 1915 the tonnage had increased to 13,348,500 tons, and the number of steamers to 6,850.

Japanese shipbuilders are now making large profits and in addition have the benefits of a subsidy, which may be described as a shipbuilding encouragement fund, the amount of the latter paid in 1917 being estimated at $1,500,000. In addition to this the industry is indirectly benefited by a bonus on marine engines. The ships now contracted for, and that are expected to be built in Japan during the current year, number 132, with an aggregate tonnage of 650,000 tons. This is divided among ten shipbuilding yards—the capacity of each yard ranging from four to twenty-seven vessels.

SHIPYARDS, LUNENBURG, N. S.

This is entirely merchant tonnage and is exclusive of warship construction. While labor is cheap in Japan, and the cost of construction is relatively low in this respect, the rate of wages there as elsewhere is advancing. For the ten year period 1905-15, the rate of wages in Japanese yards increased slightly over fifty per cent.

Canada might well study, and in some particulars might closely emulate what Japan has achieved in the development and material progress of her mercantile marine during the last ten or twelve years. The question of developing a mercantile marine is quite as important in Canada as in Japan. Indeed it is for us a very much more vital problem, and our facilities are very much superior, while our opportunities and the gravity of our situation is much greater. What are we going to do about it?

# The Source of Capable Seamen

By J. J. HARPELL.

One of the questions which is much to the fore just now is how the United States is going to handle her immense new merchant marine fleet when it is built. While she is content to have her vessels operated by foreign crews, there is little need for worry because the tonnage that has been destroyed has left a surplus of capable seamen, who, together with a regular supply of trained men that are constantly coming forward from Great Britain, Norway, Japan, Canada, Newfoundland, Iceland, Denmark and the Netherlands, are quite sufficient to handle the product of even a much larger programme of shipbuilding than the allied countries have now under way. But there is a growing feeling on the part of the American public that United States vessels should be manned by United States citizens.

Writing in the February issue of the Pacific Marine Review, Mr. H. E. Pennell, President of the Coast Shipping Company, observes:

"Owing to the fact that matters marine have so long been considered of small moment in the United States, a general knowledge concerning them is universally lacking. To be sure the large problems of financing, routing, etc., being akin to others of like character throughout the world, will be readily grasped and solved by men of finance, experience, and able minds, it will be the commonplace, everyday problems of detail, so essential to the successful conduct of the enterprise as a whole which will need most careful and wise consideration and adjustment. It is the human phase of the shipping industry which will determine its success. Without men, ships cannot be operated. Hence the man status in connection with the operation of ships is of paramount importance, and must be carefully, unselfishly and wisely considered. One matter of great importance will be the source from whence to recruit men and how best to go about it."

With this premises Mr. Pennell develops an argument calculated to place the blame for the scarcity of United States seamen at the doors of the seamen's Unions, and this view seems to be generally supported by the American press. But does not the cause lie deeper than this and "being akin to others of like character throughout the world," cannot some light be thrown upon its solution by the experience of other countries?

### The Source of Maritime Power.

This same problem of providing competent seamen presented itself on another memorable occasion, namely, when the Kaiser decided that the future of the German Empire lay upon the sea. On this occasion much careful thought and investigation was given to this same question. After a careful examination of all the factors necessary to maritime power, the German authorities decided that more depended upon the existence of an active deep-sea-fishing industry than upon any other consideration and proceeded at once to build up such an industry in the Fatherland. Up to that time the per capita consumption of deep-sea fish in Germany was exceedingly small, and, small as it was, less than 15 per cent of it was being supplied by German fishermen. But it required but a comparatively few years of vigorous propaganda on the part of the German authorities and the blessing of the Kaiser to change this condition, so that by 1911 (the last year for which there are any authentic returns) Germany stood fourth among the deep-sea fish producing countries of Europe and was rapidly gaining a better position.

There is a closer relation between the fishing industry, shipbuilding and the operation of a merchant marine and a navy than is generally recognized.

"Sea fish," says Professor J. Russel Smith, in his volume, "Industrial & Commercial Geography," is considered the cause that first led men to sail upon the ocean, and from this beginning all maritime nations have had their rise. Such was the origin of the fleets of the Phoenicians and the Greeks. The Norseman, on the inhospitable shores of Scandinavia, developed fleets where man must fish or starve. The Dutchman, who wrested the commercial supremacy of the world's seas from the Portuguese had had years of maritime training on the banks of the North Sea. The fleets of England had their origin in these same fishing grounds, and later the New Englanders became the pioneers of America, because good fishing banks were near them."

The force of Professor Smith's observations can best be appreciated by an examination of the relation which the fish producing countries of the world bear to the maritime powers and more particularly to the nations that are now producing the most capable seamen.

### The Principal Fishing Grounds of the World.

It is not generally known that the important fishing grounds of the world are only four in number, and that all four lie in the northern hemisphere, mainly north of the 40th parallel of latitude. The principal food fishes of the ocean frequent the shallow places of cool seas. The coasts of the Southern Continents are too precipitous to provide off-shore shoals and do not extend far enough into the Antarctic to secure the low temperatures required by the marketable fishes. The world must, therefore, look to the northern hemisphere for its principal supplies of edible fish.

In the order of their importance as regards production, the world's four deep sea fishing grounds are as follows:

Number One: Those lying off the northwest coast of Europe, including the North Sea, the Irish Sea and the Baltic.

Number Two: Those lying off the north-east coast of Asia, including the Sea of Japan.

Number Three: Those lying off the north-east coast of North America, including the Bay of Fundy, the Gulf of St. Lawrence, Hudson Straits and Hudson and James Bays.

Number Four: Those lying off the north-west coast of North America.

### Fishing Ground Number One.

The war has necessarily interfered with the investigations that were being carried on by the Euro-

pean countries participating in the work of international investigation and exploration of the fishing grounds off the north-west coast of Europe, so that the latest authentic statistics concerning the fish production from this area is for the year 1911, as set forth in the eighth volume of the Bulletin Statistique. According to this report, the total quantity of fish landed in the various European countries in that year was 53,110,000 cwt. The production of the principal countries participating in this catch was respectively as follows:

| Country. | Catch. Cwt. | Percent. of Total catch. |
|---|---|---|
| Great Britain | 23,920,000 | 45.04% |
| Norway | 13,641,000 | 25.69 |
| France | 3,574,000 | 6.73 |
| Germany | 3,131,000 | 5.90 |
| Netherlands | 2,620,000 | 4.42 |
| Ireland | 1,607,000 | 3.00 |
| Denmark | 453,000 | 2.00 |
| Russia | 453,000 | 0.85 |
| Finland | 277,000 | 0.52 |
| Faroe Islands | 240,000 | 0.45 |
| Belgium | 232,000 | 0.44 |

Of the total the principal areas which go to make up these grounds yielded as follows:

| | |
|---|---|
| North Sea | 44.8% |
| Norway and Polar Regions | 24.7 |
| Off the Coasts of Iceland | 8.9 |
| Off the North and West Coast of Scotland | 4.4 |
| The Skagerrak Straits | 4.0 |
| The Baltic Sea | 2.7 |
| Off the North and West Coast of Ireland | 2.4 |
| Off the West Coast of England and the Irish Sea | 1.7 |

About one-half of the fish caught in these waters are pelagic fish, that is, fish that roam in schools near the surface of the ocean, such as herring, mackerel, sprats, etc., and about one-half are demersal or bottom fish, such as cod, haddock, hake, halibut, turbot, soles, flounder, etc.

The quantities of the principal kinds of fish landed at England in the year 1913 will give some idea of the relative quantities which each specie produces. These are as follows:—

| | Cwt. |
|---|---|
| Herring | 12,183,000 |
| Cod | 5,907,000 |
| Haddock | 2,294,000 |
| Place | 763,000 |
| Mackerel | 580,000 |

An idea of the equipment necessary to produce the British catch of fish may be had from the size of Great Britain's fishing fleet in 1913. This was as follows:—

| | |
|---|---|
| Steam Trawlers | 1,701 |
| Other Steam Vessels | 1,666 |
| Motor Craft | 1,382 |
| Other Vessels | 15,858 |
| Total | 20,607 |

The total number of men and boys regularly employed in the British fishing fleet is over 75,000, and those occasionally employed numbered over 25,000.

### Fishing Grounds Number Two.

Complete statistics concerning production from the deep sea fishing grounds off the West Coast of Asia are not available, but the total value of fish taken from this area in 1913 was approximately $109,000,000. Of this, the Japanese fisheries are credited with $75,000,000, and those of Russia and China with the balance.

### Fishing Grounds Number Three.

The fishing grounds off the north-east coast of North America are fished over mainly by the fishing fleets of Newfoundland, Canada, and the United States. In 1913 the catches from these grounds were approximately as follows:—

| | Cwts. |
|---|---|
| Newfoundland | 5,600,000 |
| Canada | 5,400,000 |
| United States | 1,800,000 |

### Fishing Grounds Number Four.

The fishing grounds lying off the north-west coasts of North America are fished over mainly by the fishing fleets of Canada and the United States, and in the year 1913 produced approximately as follows:—

| | Cwts. |
|---|---|
| Canada | 2,500,000 |
| United States (including Alaska) | 6,400,000 |

The principal fish producing countries of the world in the order of their importance are therefore as follows:—

| | Which produces approximately tons per year. |
|---|---|
| Great Britain | 1,200,000 |
| Japan | 900,000 |
| Norway | 800,000 |
| United States | 410,000 |
| Canada | 400,000 |
| Newfoundland | 280,000 |
| Russia (including Finland) | 250,000 |
| France | 172,000 |
| Germany | 168,000 |
| Denmark (including Iceland) | 160,000 |
| Sweden | 120,000 |
| Holland | 115,000 |

### Relation Between Fishing Fleets and Seamanship.

Great Britain with a population of forty-five million people in 1913 had a merchant marine fleet aggregating over nineteen million tons, practically all of which was manned and navigated by British seamen.

Norway, with a population of 2,400,000 in 1913, had a merchant marine fleet aggregating 2,500,000 tons. Her vessels are invariably manned by Norwegian seamen and her seamen are also to be found in large number in the fleets of many other countries.

Japan is rapidly becoming the dominant factor in the merchant marine of the Pacific. Before the war the Japanese shipping in the Pacific represented 33 per cent of the total, but by the middle of 1917 it had increased to 55 per cent of the total. Her vessels are invariably manned by Japanese seamen who are also to be found in the fleets of many other countries.

The United States is a large producer of fish, but the greater part of it is made up of salmon and shellfish—branches of the industry that do not produce seamen, as these are largely fish which either inhabit the rivers and bays, or come up into them from the sea to spawn, when they are easily trapped, netted or dipped out with fish-wheels. The deep-sea and lake fisheries of the United States are comparatively small and account for less than 100,000 tons yearly. Moreover, many of her fishing vessels are manned by Canadians.

Newfoundlanders and Scandinavians. The United States in 1913 had a merchant marine of five million tons, but the seamen navigating these were mostly English, Canadian, Japanese, Norwegian or Newfoundlanders. A recent statement of the registration of seamen sailing out of the United States ports discloses the fact that 74 per cent of them are foreigners; 9 per cent are naturalized citizens and only 17 per cent are native born citizens of the United States.

Newfoundland, in proportion to her population, is the largest producer of deep-sea fish, and proportionately the most important producer of capable seamen. But these seamen when they leave the fishing industry have to seek employment in the fleets of other countries, because Newfoundland is neither building or providing a merchant fleet sufficiently large to absorb them. Thus these excellent citizens and the beneficial influence of this citizenship are lost to their country.

Germany, in 1913, had a merchant marine aggregating a tonnage of about the same as that of United States: and, taking into consideration the special effort that she made during recent years to encourage German citizens to go into it and into the navy, also the fact that the native-born Germans in the German deep-sea fishing fleet is from two to three times the number of native-born United States citizens in the deep-sea fishing fleet of the United States, the percentage of native-born German citizens sailing out of German ports is proportionately equal to native-born citizens of United States sailing out of American ports.

In a similar manner the number of capable native born seamen that are being produced in France, Denmark, Sweden, Holland and other countries are proportionate to the size and importance of the deep-sea fishing fleets of these countries.

Canada, next to Newfoundland and Norway, possesses the largest deep-sea fishing fleet, proportionate to her population. It, however does not bear the same proportion to the British deep sea fishing fleet which her total annual catch of fish would indicate, because, like the United States, the four hundred thousand tons above quoted include her salmon and shellfish catch. Her deep-sea fishing fleet is larger than that of the United States, and both on the Atlantic and Pacific is manned invariably by native born Canadians, who come mainly from New Brunswick, Nova Scotia and Prince Edward Island. But the Canadian deep-sea fishing fleet is still small as compared with her deep-sea fishing resources. In the past the fishing industry of Canada has not been sufficiently profitable to retain the services of the men who received their initial training therein, and the merchant marine of Canada has likewise not been receiving the attention it should, with the result that large numbers of Canadian seamen have had to look to other countries for profitable employment. They found it principally in the fishing fleets and merchant marine of the United States.

### The Deep Sea Fish Resources of North America.

The grounds third in importance as regards production and development, but first as regards extent of area are those lying off the East Coast of Canada and Newfoundland. They comprise the Grand Banks, which alone cover an area as large as that of Great Britain. These banks are the largest deep-sea fishing shoals in the world. Lying just where the cold Labrador current rounds the south-east corner of Newfoundland, these cool waters, with their abundance of food organisms that have been brought down from the Northern Seas, form the greatest cod fishing banks known. These grounds include also the Gulf of St. Lawrence, and the Bay of Fundy, as well as the shoals off the coast of New Brunswick, Nova Scotia and Newfoundland and Labrador. Furthermore, they are the grounds which produce the finest class of seamen. They are more exposed to the Atlantic than are the Dogger Banks of the North Sea. The weather is subject to more frequent and violent changes, and they possess the additional hazard of frequent and dense fogs. The quality of seamenship which these fishing grounds produce will be appreciated by the following account of their life and work, as set forth by Captain F. W. Wallace, Editor of the "Canadian Fisherman," in a volume now on the press:

### The Bank Skipper.

"Few occupations call for more tact, resourcefulness, nerve and seafaring knowledge than that of the present day master of a Bank fishing vessel. They are in a class by themselves and the work calls for smart, intelligent and hardy men.

Most of the successful fishing skippers today are Nova Scotians and Newfoundlanders — the old time Cape Cod, Maine and other native born Americans having practically gone out of the American fishing fleets. Beginning as an ordinary fisherman, the skipper is generally a man who is ambitious and with enough determination in his make-up to tackle the worries incidental to the position. He applies for command of a schooner and it is up to him to "make good." To do this, he has to get a "gang" together to go fishing with him and as a rule he will enlist the services of former shipmates, relations and friends as it is no easy matter for a "green" skipper to ship men when there are so many successful skippers always looking for hands.

With a gang shipped, the green skipper has to prove himself a "fish killer" and bring in good "trips" of fish. If fish were to be got where ever the gear was set this would be an easy matter, but unfortunately they are not and the skipper has to use his head and find them. If he is a smart man and well informed as to the migrations of the scaly spoil, he will "strike" them and land a fare. If he is unsuccessful in catching fish, his gang are liable to leave him on return to port as they work on shares and poor fares mean but little money. A few bad trips mean "finis" for the ambitious fishing skipper as he will never get men to ship with him nor an owner to trust him with command of a schooner.

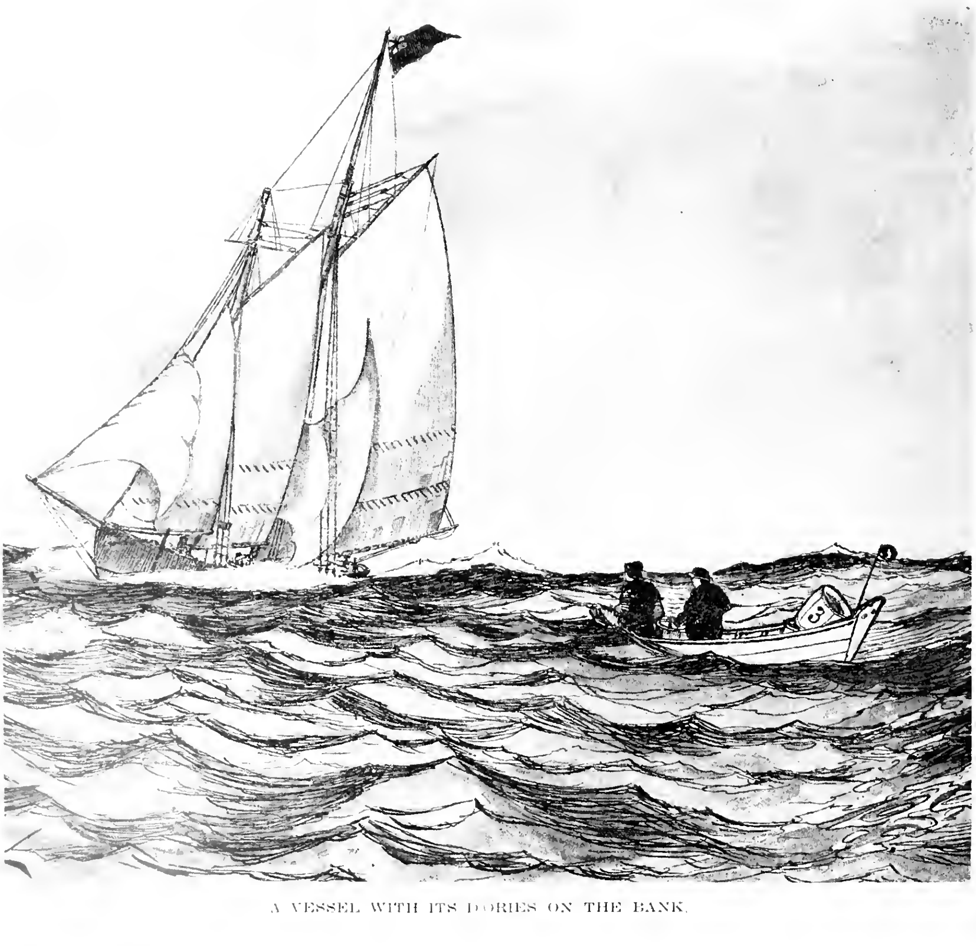
With so many independent men under his command, the skipper has to be a man of infinite tact. He cannot bully or brow-beat his "crowd" or use his authority in the same way as the officers in the merchant service. Fishing vessels have no articles and the men sign no papers of service. They ship to "fish and sail the vessel to and from the fishing grounds." They are under the Laws of Canada Shipping Act inasmuch as they must obey the just commands of the master in the navigation of the vessel. The tactful skipper never attempts to discipline the men — if he tried it they would leave him at the first port — but he has to exert his authority in such a way that he can get the work done without any appearance of "driving."

This calls for the exercise of a great deal of self-restraint, patience and good humor. The successful skipper works the men hard — fishing days and nights without sleep — but he does it in such a way that they feel in no way "rushed."

All the work of navigating the schooner falls to him and the men look to the skipper for all orders in handling the ship. He has no mate to relieve him or take responsibility—the crew merely carry out his instructions in steering, look-out and sail handling. He has to be a man of nerve to drive the schooner to market in heavy weather: to navigate around a dangerous coast in fogs and winter snow storms, and to exercise all the tricks of seamanship in the various hazardous situations which are part of life at sea. In the fishing with dories, the men will be out in them and scattered over five miles of water. The skipper, cook and probably a spare hand are in charge of the schooner and the dories have to be carefully watched in case fog or sudden squalls shut down and separate them from the vessel. All the lives of the dory-men depend upon his vigilance and ability to pick them up should anything happen.

No matter how good a fish killer a skipper is, there are times when he will hit a prolonged streak of bad luck and the men begin to growl, as seafarers will. The skipper, however disconsolate he may feel himself, has to exercise his powers of good humor and keep up the spirits of the crew. Thus it will be seen that the position of master on a fishing vessel calls for men of more than ordinary virtues and ability.

In addition, he has to be something of a business man and keep track of the markets for fish and the seasons they are in demand. He has to be a hustler in procuring bait during the various periods in which it is to be procured cheaply and he has to plan out the fishing voyage as regards time and expenses in order that it shall be profitable to the owners and crew. Supplies and gear are generally purchased by him and he has to be fully cognisant of the various fishery laws and regulations which obtains along the ports, provinces and states of the Atlantic coast.



A VESSEL WITH ITS DORIES ON THE BANK.

### The Bank Fisherman.

The Bank fisherman, or the deep-sea fisherman as he is sometimes called, is of the finest type of worker. The fisheries offshore on the Banks call for hardy, courageous men able to stand the long hours of downright hard work which the fishery calls for and also the rigors of life at sea in all weathers. Most of them haye to be born to the fisheries and have engaged in them since boyhood—very few men brought up in other environments can go Bank fishing.

The Maritime Provinces of Canada and Newfound land breed the men who engage in the Bank fisheries of the present day out of home and United States ports. As mentioned before, the native born American does not go Bank fishing nowadays — the shore occupations have claimed the sons of the old time American deep-sea fishermen and United States vessels are largely manned by Canadians and Newfoundlanders with a few Englishmen and Scandinavians.

The Bank fisheries calls for strong men. There is no place for a weakling or a man troubled with nervousness. The work is hazardous and demands ability to cope with physical strain and nerve enough not to get frightened easily. The Bank schooner has to remain at sea often in the wildest of winter weather. Gales which play havoc with great ocean liners are rode out by the little 90 ton fishing schooners and handling the vessel at such time called for hardihood and seamanship on the part of the crews. The dory fishing in which one or two men leave the schooner in small boats to set and haul their fishing lines is often attended with great danger. The sea may be smooth when the dories leave the vessel and may be lashed by a gale before they can get aboard again. Sudden snow storms and dense fogs are two hazards which the dory men have to tackle and it requires a knowledge of unusual seamanship and weather lore to escape destruction.

In spite of the hazards and the roughness of the life at sea in small craft, the work appeals to the Bank fishermen because of its independence and freedom. There is no one to "boss" and order them around except the skipper and he, as already explained, exerts his authority in a mild way. Master and crew work together in a co-operative manner and this policy and the freedom from discipline is the principle which keeps men engaged in an occupation which calls for more risks than the remuneration covers.

Besides being an expert in the work of fishing, rigging lines and gear, the Bank fisherman must be an able-bodied seaman as well. He must know the compass and how to steer by the wind or a course. He should be able to go aloft and handle a topsail: lay out on a bowsprit and furl a jib or on a boom end and haul out the reef-earring of a mainsail. A knowledge of the rule of the road is essential as he has to stand a watch and, in addition to being able to handle a schooner and her canvas, he must know how to splice and knot. Until he is an expert in pulling a pair of oars and handling those tricky yet wonderful boats called dories in all kinds of weather, he is not fit to go Bank fishing. As a small boat sailor, the Bank fisherman is the finest in the world.

A Crew of Bank Fishermen from Lunenburg, N.S. Captain Maynard Colp, whose vessel was the high liner for 1917, is seated in the centre.

### The Atlantic Deep-Sea Fishing Ports.

The Bank fishery of the United States is carried on from the ports of Gloucester and Boston with a small fleet from Portland, New York and Provincetown. The Bank fishery of Canada is conducted principally out of Lunenburg, N.S., where a fleet of some 125 schooners engage in the salt fishing. Out of Digby there is a small fleet of eight or ten schooners which engage in fresh fishing. Yarmouth, Lahave, Lockport, Halifax, Canso, Hawkesbury and some ports in Prince Edward Island, New Brunswick and Quebec have a few schooners employed in Bank fishing.

### The Bank Fleet's Season.

The great Lunenburg fleet engage exclusively in salt fishing — that is, all the fish caught are salted and

after landing are dried and prepared mainly for export to Europe, the West Indies and South America. The Lunenburg craft fit out for the season's fishing in March and continue throughout the summer until September or the beginning of October. After that, the fleet is laid-up for the winter, with the exception of a few large schooners which run with fish and lumber to the West Indies and return with salt from Turk's Islands.

The Spring fleet usually procure their herring bait from one or other of the freezers established in Nova Scotia ports and sails for the Banks around the 15th of March. They remain at sea until about the first of June when they return and land their fares at Lunenburg and sail for the Magdalen Islands to procure a baiting of fresh herring which is plentiful then. With this baiting, or a baiting of caplin—a small fish which school in great number around the Newfoundland coast — the fleet fish upon the various Banks from Western to Grand from June to September. The Spring trip is generally a small one and the average catch for each vessel is about 1,000 quintals—a quintal being 112 lbs. The Summer voyage is the longest and the schooners may return with a fare ranging from 1,000 quintals to 2,400 quintals according to the luck and the weather. Most of the fish caught is cod with some hake, pollock, cusk and haddock."

### The Deep-Sea Fishing Fleet of the Pacific.

The fishing grounds of fourth importance in point of production, but third in extent of area are those lying off the west coast of Canada and Alaska.

Except for halibut, the deep-sea fishing on these grounds have had little or no attention. The halibut fleets of the Pacific fish out of Prince Rupert, Vancouver and Seattle.

### The Deep-Sea Fishing Resources of North America and How They Might be Developed.

Proportionate to their resources the people of North America have made little progress in the development of their deep-sea fishing industry. This continent lies in the closest proximity to the two of the world's four deep-sea fishing grounds and her inland fisheries, comprising lakes as large as seas, are greater than those of any other country.

The road to the proper development of these resources lies along the following lines:

(1) The larger consumption of fish on the part of the people of the United States and Canada.

(2) The dissemination of more information concerning the fishing industry among the youth of the country.

(3) The establishment in the educational institutions of courses of study in pisci-culture, navigation and other subjects calculated to produce the expert knowledge necessary to the proper development of the fisheries and to make the industry profitable.

(4) The proper surveying of the deep-sea fishing grounds so as to make the business of harvesting these grounds less haphazard and more scientific as well as more productive and not so liable to loss of gear and other equipment.

An international commission, representing the United States, Canada and Newfoundland, should be appointed to do the work for the fishing grounds off the east and west coast of America which the International European Commission has been doing for the grounds off the north-west coast of Europe.

### The Deep-Sea Fisheries is Capable of Much Increased Production.

Heretofore the interest which the people of the United States and Canada have taken in fish as a food has been allowed to develop in a most indifferent manner, with the result that there is a demand only for the few varieties of fish that happen to be best known or most easily handled in the kitchen. Many other varieties, equally nutritive and palatable, have been left uncaught, or if caught have been thrown back into the sea, because there was little or no market for them. This condition has left the business of deep-sea fishing generally unprofitable, and the few varieties of fish in demand high in price to the consumer. For the greater part of their catch, the deep-sea fishermen of North America have had to look for a market in other countries.

Strange as it may seem, statistics have not been compiled by the United States authorities concerning the total catch and the quantities of each variety taken by the fishermen of that country. The same is also true of Newfoundland. So that the only complete available returns that are to be had are those concerning the Canadian catch. In the year ending with the 31st of March, 1917, the quantities of all kinds of fish—deep-sea, inshore and inland—taken by Canadian fishermen, together with the average price at port, of each kind were as follows:—

| Kind. | Quantity. | | Value. | Value per lb. Cts. |
|---|---|---|---|---|
| Cod (deep sea) | 2,026,231 | cwt. | $ 5,449,964 | 2.68 |
| Herring (inshore) | 1,749,397 | " | 3,050,421 | 1.84 |
| Salmon (inshore) | 1,239,668 | " | 10,882,431 | 8.77 |
| Haddock (deep sea) | 582,028 | " | 1,711,271 | 2.94 |
| Lobster (inshore) | 480,898 | " | 5,508,054 | 11.45 |
| Hake and Cusk (deep sea) | 385,953 | " | 757,456 | 1.99 |
| Sardines (inshore) | 315,831 | bbl. | 1,481,261 | 4.69 |
| Whitefish (inland) | 164,992 | cwt. | 1,135,486 | 6.88 |
| Mackerel (deep sea) | 156,075 | " | 924,746 | 5.93 |
| Pollock (deep sea) | 143,306 | " | 268,756 | 1.87 |
| Halibut (deep sea) | 142,823 | " | 2,263,573 | 15.85 |
| Pickerel (inland) | 105,423 | " | 871,719 | 8.27 |
| Trout (inland) | 88,071 | " | 741,610 | 8.42 |
| Pike (inland) | 73,993 | " | 404,453 | 5.46 |
| Alewives (inshore) | 73,416 | " | 117,083 | 1.59 |
| Smelts (inshore) | 68,629 | " | 847,357 | 12.35 |
| Tollibee (inland) | 58,537 | " | 301,060 | 5.14 |
| Clams and Quohogs (inshore) | 54,942 | bbl. | 195,805 | 3.56 |
| Caplin (inshore) | 22,784 | " | 22.784 | 1.00 |
| Perch (inland) | 22,773 | cwt. | 114,656 | 5.04 |
| Carp (inland) | 22,303 | " | 56,543 | 2.53 |
| Oysters (inshore) | 18,361 | bbl. | 147,751 | 8.05 |
| Dulse, crabs, cockles, etc., (inshore) | 17,035 | cwt. | 53,917 | 3.15 |
| Tom cod (inshore) | 14,314 | " | 42,531 | 2.98 |
| Albacore (deep sea) | 13,906 | " | 48,684 | 3.50 |
| Eels (inshore) | 14,068 | " | 87,050 | 6.18 |
| Oulachons (inshore) | 12,990 | " | 68,449 | 5.39 |
| Mullets (inland) | 10,802 | " | 21,604 | 2.00 |
| Scallop (inshore) | 9,460 | bbl. | 38,460 | 4.06 |
| Catfish (inland) | 9,392 | cwt. | 74,068 | 7.88 |
| Swordfish (deep sea) | 9,284 | " | 69,716 | 7.50 |
| Shad (inshore) | 8,365 | " | 63,645 | 7.60 |
| Flounder (deep sea) | 7,924 | " | 36,560 | 4.61 |
| Squid (deep sea) | 7,802 | bbl. | 36,977 | 4.75 |
| Goldeye (inland) | 6,605 | cwt. | 32,554 | 4.93 |
| Soles (deep sea) | 6,226 | " | 60,383 | 9.70 |
| Sturgeon (inshore) | 5,940 | " | 66,420 | 11.18 |
| Dog fish (deep sea) | 5,460 | " | 1,911 | .35 |
| Skate (deep sea) | 2,982 | " | 8,643 | 2.90 |
| Bass (inland) | 2,481 | " | 29,329 | 10.94 |
| Octopus (inshore) | 161 | " | 2,012 | 12.49 |
| Muskinonge (inland) | 93 | " | 982 | 10.53 |
| Whiting (deep sea) | 87 | " | 1,087 | 12.50 |

From this table it will be seen that the most expensive fish to produce is the halibut. Yet this is the

fish for which there is the greatest demand. It is the most difficult fish to catch and this difficulty is ever increasing, by reason of the fact that the specie is becoming scarcer. In fact, the halibut is disappearing so rapidly from the fishing grounds, that the United States and Canada are considering some international agreement with a view to protect them. The production of halibut has long since dwindled to small proportions on the fishing grounds off the northwest coast of Europe and the northeast coast of Asia. The production from the grounds off the northwest coast of North America is also small, so that the demand in the world's markets for this fish must be largely satisfied by the supplies from the deep-sea fishing grounds off the northwest coast of North America. The quantity taken by Canadian fishermen off the Atlantic

A Section of a Fishing Fleet at Rest.

and Pacific coasts during the last five years was as follows:

| | |
|---|---|
| 1912-3 | 282,658 cwt. |
| 1913-4 | 256,096 " |
| 1914-5 | 239,920 " |
| 1915-6 | 226,151 " |
| 1916-7 | 142,823 " |

Out of the total annual production in Canada of all kinds of fish from both the Atlantic and the Pacific and her inland fisheries of 8,170,000 cwt. the halibut accounts for only 142,823 cwt. Yet everybody seems to want halibut.

Salmon is the next most expensive fish, particularly when purchased fresh out of season, which means the greater part of the year, because salmon are plentiful only while they are going up into the rivers to spawn. This spawning season is never longer than a few weeks at any one point. At this time the salmon are taken in large quantities and canned. The low prices paid for them at this time of the year tends to bring down the average for the season to the figures given in the above table. Ther are several species of salmon on the Atlantic and Pacific Coasts and inland lakes, and fortunately the species do not all spawn at the same time of the year. At certain times of the year out of the spawning season the few stray salmon caught with a hook and line, or in a net, will sell as high as $1.00 a pound.

The smelt is the next most expensive fish for the reasons that the demand is large, they are an expensive fish to produce, they can be bought only at certain times of the year, and the total production is not large. The same is also true of the whitefish, trout, bass, pickerel, dore, catfish, swordfish, soles, muskelonge, whiting and sturgeon. The octopus, or devilfish, also sells high, because the demand, particularly among the Oriental people, is much greater than the supply. They are caught mainly on the Pacific Coast where they are generally consumed by the Chinese and Japanese.

The cheap fish are cod, haddock, hake, cusk, pollock and skate. These are cheap, not because they are less nutritive or less palatable, but for the reason that they are most abundant, easily caught and may be had at any time of the year, weather permitting. The herring is also a cheap fish because so abundant. It is the most prolific food fish in the ocean and especially plentiful off the northeast and northwest coasts of America. But unlike the cod it cannot be had at all times of the year. There are certain seasons when the herring appear in great numbers off the shores and at these times the quantities taken are limited only by the equipment for catching them, the cold storage and curing facilities for taking care of them and the demand in the market.

All the above mentioned cheap varieties are deep-sea fish and the deep-sea fisherman could produce many times their present catch if the consumption among the people of the United States and Canada was only increased accordingly.

If the people of the United States and Canada wish to become a marine power, they should pay more attention to the development of the deep-sea fishing resources, with which nature has so lavishly endowed the shores of this continent.

## A NEW CUTTING STEEL.

Word has come that is of much interest to American mechanics. The English have recently invented a strong and superior high-speed steel. Such news to the layman may mean little. But to those who know, it is as welcome as the news of a great land victory. Why? Because that side which can turn out war machinery the fastest will win the war!

With this new total steel — "coalterom," it is called—engines and guns can be worked faster without the added heat that develops and affects hardness and rigidity.

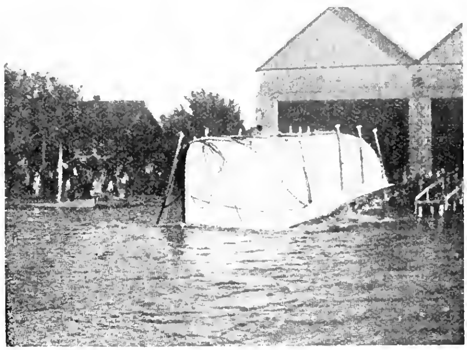
Tools of this steel can be cast into shape, and casting is the quickest known way of making any tool. There are few steels, however, which by casting them do not become brittle. "Coalterom steel," nevertheless, can be made in this manner instead of having to be forged and rolled, two very much lengthier and more expensive processes.—Popular Science.

# Launching Concrete Boats Bottom Up

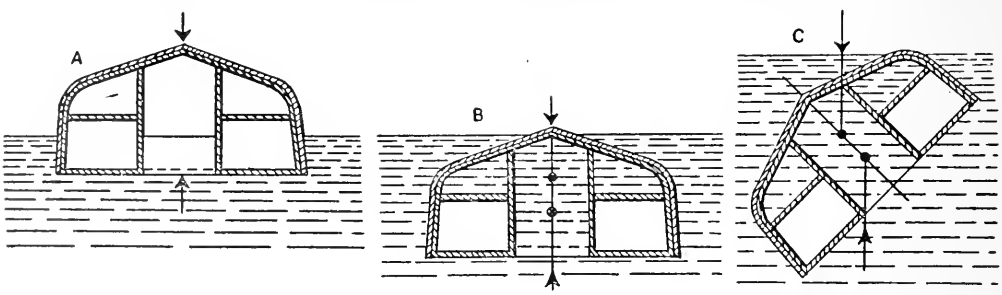
## Norwegians are shipbuilders of old. Now they've devised a new way of building and launching vessels

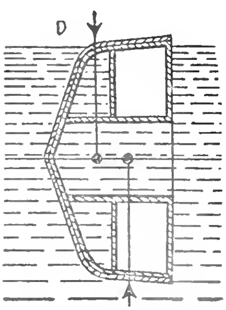
EXTRACTED FROM "POPULAR SCIENCE," MARCH, 1918.

Launching a two-hundred-ton concrete vessel bottom up may sound fantastic, but it has recently been done with success by a shipbuilding company in Norway. The vessel was a reinforced concrete lighter (concrete strengthened by a skeleton of steel strips), and consisted of an inner hull of wood which served as a mould for the whole structure. When completed, there rested upon the launching ways the inner wooden mould divided into watertight compartments, and the outer concrete hull, both bottom up. An inner compartment was left open at the bottom, so that water entered as the vessel left the ways, the air escaping through pipes in the hull. When this compartment was completely flooded, the water then reached the level of the two upper side compartments, causing the boat to lose its buoyancy and submerge to a position of unstable equilibrium. In this position, a slight list to one side caused the boat to heel over completely and float to a normal position.

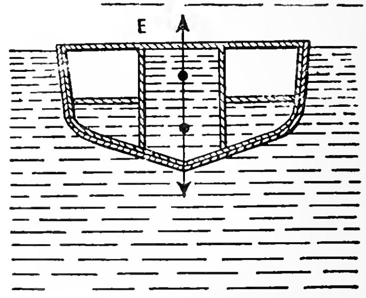


Though launched bottom side up, and with a wooden form inside, the big boat slid smoothly into the water.




Position A shows the boat just entering the water, the wooden form inside, and all of its watertight compartments full of air. In position B—water has entered the center compartment and also those along the bottom, the air escaping through vents. At C—the two lowest compartments, closed to the water, are buoying up on the boat and causing it to turn over. Drawings D and E show further stages. The water is afterward pumped out



# Shipping Notes

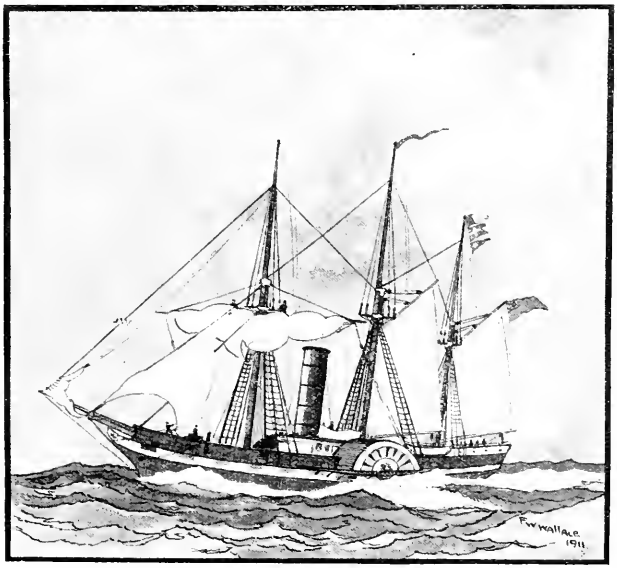
## AN INTERESTING INCIDENT IN CANADIAN SHIPBUILDING.

By Captain F. W. WALLACE.

It is interesting to note that Canada has taken quite an important part in the development of the means of propulsion which helped primarily in driving the white sailed clippers from the seas, and incidentally, her own old time merchant marine. The "Accomodation" built by Molson at Montreal in 1809, was the first passenger steamer to ply upon British Colonial waters, and ran between Montreal and Quebec. The first steam vessel to make a transatlantic passage was also built and owned by Canadians. The "Royal William," as she was called, was built at Cape Blanc, Quebec, by George Black and J. S. Campbell for the Quebec and Halifax service of a Quebec company. She was built of wood on a clean lined semi-clipper model, 176 feet overall, keel 146 feet, breadth of beam inside paddleboxes 29 feet 4 inches, breadth outside paddleboxes 43 feet 10 inches, depth of hold 17 feet 9 inches. Her measurement tonnage was 830 tons. On April 29th, 1831, she was launched and christened after the King, by the wife of the then Governor-General. Lord Aylmer. She was towed to Montreal, where her engines were installed by Bennett and Henderson, and in the fall of the year made one or two trips to Halifax. Although she had auxiliary sails to assist her engines in favoring winds. The "Royal William" was propelled by steam alone.

When in Halifax she came under the attention of Samuel Cunard, founder of the Cunard Line, and he became very much interested in her, and ultimately became a director in the company which owned the vessel. It is said that it was through his connection with this little steamer that the mighty fleet which bears his name was formed.

In 1832, trade being very poor in Canada, it was thought advisable to send "Royal William" across the Atlantic to be sold, and on August 4th, 1833, she left Quebec for London, under the command of Captain McDougall. After coaling at Picton, N.S., she arrived at Gravesend on September 11th; coaling again at Cowes in the Islands of Wight on her way. Her passage time between port and port was 25 days during which she steamed all the way.




The "Royal William"

## LAUNCHING OF THE "BEATRICE CASTLE"

With the launching of the "Beatrice Castle," which, it is reported, will soon be turned over to W. B. Castle, of the Zena Iron Works, Duluth, British Columbia shipyards have completed their contract with the Canada West Coast Navigation Company. Six of the vessels, which are wooden auxiliary schooners specially designed for the lumber trade, were built by the Wallace Shipyards at North Vancouver, and six by the Cameron-Genoa Mills Shipbuilders, Victoria. Both these companies are now making preparations for handling their next contracts, details of which have not yet been announced.—(Pacific Marine Review.)

## A BRITISH COLUMBIA YARD.

The firm of J. Coughlan & Sons is a private enterprise, owned and controlled by Mr. J. Coughlan, one of the pioneers of British Columbia, and his two sons, Mr. J. J. Coughlan and Mr. S. H. Coughlan.

Prior to the war the firm was engaged in the sale and fabrication of structural steel for railway and highway bridges and steel frame buildings, as well as in the manufacture of building bricks. They were highly successful in these regards, having constructed almost all of the steel frames now standing in British Columbia, as well as a number of railway bridges; the advent of war, however, put a stop to the demand for materials of this nature, and consequently other fields of endeavor had to be sought.

Contracts were secured for six steel vessels of 8,800 tons dead-weight capacity, all for delivery prior to the end of the year 1918. These are the largest steel vessels being constructed in Canada, and will be a credit to the premier port of British Columbia.

It was necessary to entirely overhaul and re-equip their fabricating plant, and in this regard no expense has been spared, so that to-day the fabricating capacity of this yard will compare very favorably with any yard north of San Francisco. Four keels have been laid down and construction work is proceeding simultaneously on three vessels, the first of which will be launched very shortly.

These vessels are to be driven by turbines which have been contracted for in the United States; the Scotch boilers, however, will be built at the yard of J. Coughlan & Sons, in Vancouver.

At the present time this firm is giving employment to more than 1,000 men, and it is expected that before the work is completed the present staff may be doubled.

It should be borne in mind that greater difficulties have been confronted in building these vessels in Canadian ports than in American ports, for the reason that it is more costly to obtain material, due to the higher freight rates paid and the small percentage of duty which is paid on many materials actually entering into the construction of the vessels. In addition to this, many commodities are used, such as lubricating oils, fuel oil, acetylene, etc., the cost of which is much higher in Canada than here in the States. Nevertheless, it is expected that these contracts will prove to be the foundation of a permanent and flourishing industry for the port of Vancouver.—(Pacific Marine Review.)

## HEAT-TREATMENT OF CHAIN CABLE.

(From "Machinery," Sept., 1917.)

"An exhaustive investigation of the heat-treatment of wrought-iron chain cable was recently presented to the American Society of Mechanical Engineers by Messrs. W. W. Webster and E. L. Patch, the main point under investigation being the causes of the comparative weakness of power-forged wrought-iron cable. The investigation became necessary after the steam-hammer process replaced hand forging, in 1914, in the United States navy yards. The power process was satisfactory to the extent that it effectively and cheaply welded the chain, but unsatisfactorily in that the chain, though apparently perfect, would not meet the breaking-strength requirements, while the hand-welded chain was successful under test, although it was not so thoroughly welded as the hammer-welded. One explanation of this phenomenon is: The hammer-welded link is so stiff, due to the extra work put on it, that the shearing stress can build up in the quarters to such a degree that the link will fail by shearing, whereas the hand-welded link is soft and ductile enough to deform under the shearing stress, failure occurring later, due to a combination of shear and tension when a higher tensile load is applied.

A very thorough and interesting investigation was made to ascertain whether by a simple heat-treatment the power-forged chain could be put into a reliable condition. The material used was refined iron that contained 0.1 per cent of carbon, 0.1 per cent of silicon, 0.008 per cent of sulphur, and 0.085 per cent of phosphorus. The practice of annealing is not commended, but heating to 950 degrees C. and cooling in air decreases the tensile strength and yield point, and increases the ductility of the metal and its resistance to shock. But this treatment increases the strength as well as the ductility and resistance to shock of the link as a whole. Prolonged heating and protracted cooling reduce the resistance to impact. Heating to lower temperatures than 950 degrees C. does not give such good results, and no advantage is gained by going beyond this temperature."

Note.—The above is printed as it appears in "Machinery," but a part towards the end is not quite clear. The meaning is most likely that annealing, while increasing the ductility and resistance to shock, decreases the tensile strength and yield point and is therefore not advisable; but that a special treatment, which consists of heating to 950° C. (1740° F.) and cooling in air, has been found to increase the strength as well as the ductility and resistance to shock, and is therefore recommended for power-forged links.—Editor.

## BAILY AUTOMATIC ELECTRIC FURNACES FOR HEAT TREATING SHELLS.

The use of electrical heat for operating furnaces for the annealing and heat treatment generally of steel has been developed by Mr. Baily, and furnaces of this kind have been constructed by the Electric Furnace Company of Alliance, Ohio.

In the Metallurgical and Chemical Engineering for February 1st, 1918, p. 156, appears an account of Baily furnaces adopted for the automatic heat treatment of shells. This appliance consists of two furnaces, each of which is electrically heated on the resistance principle, and provided with automatic means for advancing the shells through the furnace. The shell passes through the first furnace, being advanced by automatic pushers through the entrance door, and remains in the furnace until a pyrometer indicates that it has attained the necessary temperature. When this has been reached automatic machinery pushes the shell out out of the furnace and allows it to fall into a pit where it is immediately quenched by jets of water — the shell meanwhile revolving to insure uniform cooling. Immediately the shell has been quenched it is withdrawn and placed in the next furnace, where it goes through a similar operation for drawing the temper to the desired extent; all the operations being carried out automatically by machinery under the control of pyrometers in each furnace.

# Notes from Hamilton

The Steel Co. of Canada has started blast furnace "A" once more. The furnace has been closed down from December 15th till February 21st on account of the shortage of coke. This furnace has a capacity of foundry iron of about six thousand tons per month and, as a foundry man in the city put it, the long shutdown was causing a panic among the foundries in these parts. The Steel Company uses all the iron from furnace "B," the larger of their two furnaces, in their own open hearth plants, so the foundries have had great difficulty in securing pig iron.

The new sheet mill of the Steel Company of Canada is running smoothly, though as yet hardly up to capacity. The Dominion Sheet Metal Company, who have made heavy purchases of the sheets so far rolled, report the quality of the material to be excellent.

The Dominion Steel Foundry are putting up a new power house. They have been suffering from a shortage of compressed air, and have even been obliged to obtain additional air by piping it from the Hamilton Bridge Works plant, which is just across the street. The new power house is expected to relieve this shortage.

The work of many of the iron and steel companies has been a good deal interrupted during the past month by repeated failures in the "Hydro" Power. War work in these parts has taxed the power output to its utmost limit, and indeed beyond it. With longer days coming, it is hoped that conditions will improve.

The Wilputte Coke Oven Co. are pushing the new coke oven plant for the Steel Co. of Canada with the greatest energy. The engineer in charge reports they have been able to run continuously in spite of cold weather as they have about a thousand yards of concrete to pour inside the buildings.

Burrow, Stewart and Milne Co., Ltd., report remarkable activity in the stove business. Orders that usually dropped off in October or November are still continuing briskly. This may be accounted for in several ways; for one thing, the intensely cold weather, together with the poor supply of natural gas in these parts, has given rise to large sales of "kitchen heaters," which are coal attachments for gas stoves. Another reason may be the great difficulty in obtaining raw material.

Wilkinson and Kompass, wholesale iron and steel merchants, report an immense increase in the volume of their business. They now handle steel bars up to 6"and 7" diam., besides many other heavy sections. This is due partly to the increase in the shipbuilding industry in this vicinity, and partly to their going more fully into the mill supply business.

Mr. C. H. Strube, who for a number of years has been superintendent of the west end shops of the Hamilton Bridge Works Company, left this company on Feb. 15th to take up similar work in New York, and Mr. J. Gordon Jack has been appointed his successor. Mr. Jack had his early training with William Bain and Co., of Coatbridge, Scotland; later he was employed by the Sir William Arrol Co. of Glasgow. Since coming to this country, about eight years ago, he has been chief shop inspector for the Lackawanna Bridge Co., Buffalo, and for about four years shop and field inspector for the C.P.R.; during which period Mr. Jack became familiar with most of the shops in this part of the country. Somewhat over two years ago Mr. Jack joined the staff of the Hamilton Bridge Works Co. as superintendent of erection of the superstructure of the Don section of Bloor Street Viaduct, Toronto, where he worked hard for a year and eight months.

Mr. Albert E. Hampson has been appointed shop superintendent of the Burrow Stewart and Milne Co., Ltd., Hamilton. Mr. Hampson entered the service of this company, as a boy, over twenty years ago. He worked his way up through the shop to the position of salesman in the show room. Later, he entered the office of the company, where he spent a number of years. Mr. Hampson is still a young man, and is to be congratulated on his recent success.

Mr. J. Harris, formerly with the Steel Co. of Canada, and later with the Imperial Munitions Board, has been appointed superintendent of the Bar Mills and other parts of the plant of the Dominion Steel Foundry, Hamilton. Mr. Harris has been with the foundry for more than a year in the capacity of scrap purchaser.

## THE MANITOBA STEEL & IRON CO., LTD.

The organization meeting of the Manitoba Steel & Iron Company, Ltd., was held in the city of Winnipeg recently, and the following Board of Directors was elected for the ensuing year, viz.:—T. R. Deacon, H. B. Lyall, Sir Augustus Nanton, Feo. F. Galt, G. W. Allan, K.C.M.P., Sir Douglas Cameron, Chas. Pope, Capt. Wm. Robinson, W. H. Cross.

At a subsequent meeting of the Directors the officers were elected as follows:—T. R. Deacon, President; H. B. Lyall, Vice-President; Walter Stuart, Secretary.

The company has been incorporated with a Dominion Charter with an authorized capital of five hundred Thousand Dollars ($500,000.00) to take over the merchant end of the business of The Manitoba Bridge & Iron Works, which has grown to considerable dimensions.

The new company is strongly financed and will carry on a general merchant business in heavy steel goods such as structural steel, plates and sheets, bar iron and steel, boiler tubes, rivets, bolts, railway supplies, mining equipment, heavy forging billets and stock for shipbuilding. An entire block of land with suitable warehouse has been secured on Logan Avenue with railway siding facilities and business will be commenced on March 1st. The business will be carried on along lines similar to the large steel and iron merchant businesses of the United States, contracts for large tonnages being made at one time with the rolling mills. Authority is also given under the charter to build and operate rolling mills and blast furnaces.

The Manitoba Bridge & Iron Works purpose confining their business more to the purely manufacturing side of the business, for which this change will afford them more needed room on their present site. The latter company is also applying for a Dominion Charter with an authorized capital of one million dollars ($1,000,000.00).

# Iron Ores

W. G. DAUNCEY.

As a preliminary statement we may define what is meant when iron ore is mentioned, it is the ferruginous substance as found in nature. We can ignore the rare instances where iron is found in a pure state and confine our attention to the ores as usually found and as of importance to the trade. When mined they are intimately associated with matrix, or vein-stuff, and it is necessary to ascertain the metallic content before deciding whether they can be worked with profit. The poorest ores mined in England are those of the Cleveland district and contain about 33 per cent. metallic iron, whilst in the States some Ohio ores containing only about 25 per cent. metallic iron are regularly mined. Owing to special conditions ores even poorer than these are sometimes mined, but in such cases the accompanying material usually possesses marked fluxing characteristics. It is necessary that iron ores, besides possessing a stipulated metallic content, should be relatively free from such elements as phosphorus and sulphur. Spain contains enormous deposits of iron pyrites ($Fe\ S_2$) as also does Russia, but as their importance is chiefly for the copper they contain and for the manufacture of sulphuric acid they need not be discussed here. As regards Canadian ores, and for the purpose of this article we include Newfoundland, much has yet to be learned, but sufficient information is available to allow certain definite statements to be made. The actual value of an iron ore depends upon many factors, its quantity, quality, and general freedom from deleterious elements; the ease with which it can be mined and freed from foreign matter, and its proximity to coal and limestone. The questions of transportation and accessibility to available markets are also important. The cost of producing iron from ores will also be materially affected by the percentage of copper, chromium, manganese sulphur and phosphorus present in the ore. Owing to the ever changing importance of these factors the advantages of given districts will constantly change, and the place of small value to-day may be important to-morrow. The basic process is most suitable for making steel from the iron derived from most Canadian ores, but the development of electro-metallurgy may revolutionize present practice within the next few years. There are many places in Canada where deposits of iron ore are known to exist, but where the quantity available would not justify the erection of a costly modern blast furnace plant, and these may be actively developed by the aid of electric furnaces. It is probable that many of these deposits would repay the expenditure necessary to erect electric furnaces, but could not be considered if blast furnaces were essential. In many parts of Nova Scotia, deposits of iron ore are known to exist, but these have generally been looked upon as too limited in extent to merit serious consideration. The most important deposits now available are in the Maritime Provinces, Quebec and Ontario, but those of British Columbia are worthy of a note because of their potential value. Newfoundland has the well known Wabana Mine, on Bell Island; for several years this was worked by open cut, the ore being accessible as soon as the surface covering was removed. This deposit is the chief source of iron ore supply for Nova Scotia. The upper bed on this property has an area of 240 acres and a thickness of six feet; while the lower bed has about 817 acres in sight. When these two sources are exhausted, submarine operations can provide an incalculable additional supply. The Maritime Provinces and Newfoundland possess excellent coal measures, good fluxing materials, and iron ore deposits of great commercial value. Quebec, although not so favorably supplied as Nova Scotia, possesses important deposits; north of Montreal many deposits have been located, usually of the magnetic type, but these have generally too much titanium for satisfactory smelting by present methods. Another possible supply is contained in the magnetic iron sands, which, although heavily impregnated with titanium, are particularly free from phosphorus and sulphur, and will be economically worked at no distant date. At present the most important deposits in Quebec are the bog iron ore beds, especially those in Champlain, St. Maurice, and Batiscan Counties, but the lack of satisfactory fuel is a serious handicap to their development. Coal has to be brought from Nova Scotia or Pennsylvania. Ontario is more liberally supplied with iron ores than either the Maritime Provinces or Quebec, and possesses an enormous area of rock favorable to the occurrence of ore deposits. In Northern Ontario the rock formations are very similar to those found in Michigan, Wisconsin, and Minnesota. The most important deposits are, the Helen, Josephine, and Magpie Mines, in the Michipicoten district. In the Helen Mine the ore bed is approximately 200 feet deep, 400 feet thick and 1,000 feet in length; this yields a good grade of haematite. The Josephine Mine, and the Magpie Mine both contain large deposits of ore, but are not enough developed for their extent to be estimated. Amongst other places where ores have either been worked or discovered may be mentioned, Atikokan, Loon Lake, Black Sturgeon River, Moose Mountain, Wilbur and Bessemer. Of these Moose Mountain is probably the most important as it yields a hard compact magnetite of a higher metallic content than the haematite of the Helen Mine, it is low in sulphur and phosphorus, and quite free from titanium. Unless the peat-bogs of the province can yield a substitute for coal, coke or coal will have to be imported from the United States or from Nova Scotia. The alternative course, if Ontario is to develop her iron and steel industry, is to resort to electro-metallurgy and to utilize the available water power.

To be of value to the industry iron ores must be easily and economically fluxed in the blast furnace and must be free from elements which would in any way interfere with the working of such a furnace. In practice it is found that only oxidized compounds answer these conditions therefore the ore must be an oxide or a carbonate. We can place the useful ores in three classes:

I.—Magnetite, or magnetic oxide.
II.—Haematite, or ferric oxide.
III.—Spathic ores, or ferrous carbonate.

In class I. we get the pure magnetites, and magnetites in which another metal had replaced part of

the oxide of iron, such metals being chromium, titanium, and zinc.

In class II. we get red haematite, or anhydrous ferric oxide and hydrated ferric oxide including brown haematite, limonite, and bog-ore.

In class III. we may place pure spathic ores, and carbonate ores associated with clay (clay ironstones and argillaceous ores), or with bituminous matter (black band).

Pure magnetites occur in well defined octahedral crystals, sometimes as much as an inch in length and at others in the massive form where individual crystals cannot be distinguished by the unaided eye. The hardness is 6 on Moh's scale, its density is about 5, it gives a black streak, and is brittle. It is unvariably, attracted by a magnet even when itself not magnetic, is black in color, and has a well defined metallic lustre. When pure, magnetite is the richest ore of iron and contains 72.4 per cent of metal. With these ores is generally found upwards of 10 per cent of gangue, as quartz or some other form of siliceous matter; and sometimes silica and lime occur in such proportions as will produce a self fluxing ore in the blast furnace. They are generally free from phosphorus and sulphur, but occasionally iron pyrites is present, and then weathering or calcining before smelting becomes necessary. Besides the relatively pure magnetites, we have those in which either the ferrous or ferric oxide has been replaced by the oxide of another metal such as Franklinite or zincite, ilmenite or titanic iron, and chromite, or chrome iron. This latter is the source of the chromates which in turn supply the colouring in many pigments, glasses and enamels. It is common to apply the term haematite to a number of minerals, all of which consist essentially of anhydrous ferric oxide ($Fe_2 O_3$) and give a red streak; in many cases the ore has a distinct red color, but this is not always so. Red haematite sometimes occurs in the crystallized form in small irregular crystals which belong to the hexagonal system; its maximum hardness is 6 on Moh's scale, and its greatest density about 5.2, but many are porous and soft. The more important varieties of this ore are: specular iron ore, which is a very pure form occurring in brilliant crystals; micaceous iron whose glistening dark-grey scales resemble mica and from which fact it derives its name: kidney ore whose mass is made up of concentric layers and usually has a bright-red color. When pure, ferric oxide contains 70 per cent of metallic iron, but the usual percentage is around 60. Brown haematite is the term generally employed to distinguish a number of minerals all of which consist essentially of hydrated ferric oxide; they vary in color from bright yellow, passing through brown to almost black but always give a brown, or yellow, streak. It is possible to divide these minerals into two classes—goethite ($Fe_2O_3 .H_2O$) which usually occurs in well formed brilliant crystals; its hardness is 5 to 5.5 and its density about 4, and when pure contains about 63 per cent of metallic iron. In the second class we have limonite ($Fe_2O_3, 3 H_2O$), commercially of much greater importance than goethite, which most commonly occurs in the earthy form, but also in cellular and compact masses. This ore usually contains at least 10 per cent of combined water: 10 to 20 per cent of silica, and about 0.6 of phosphorus, and, as mined usually contains about 45 per cent of iron. In class three we place the ores which consist essentially of ferrous carbonate and are of great importance. For simplicity we can put these into four sub-sections:

I.—Spathic iron ore.
II.—Impure carbonates.
III.—Cleveland ironstone.
IV.—Blackband ironstone.

No. 1 is the purest form in which ferrous carbonate occurs in nature and contains a maximum of 48.5 per cent. of metallic iron. Its hardness is 4 and its density about 3.8, with a white, or nearly white, streak. This ore frequently contains sufficient manganese to enable it to be used in the production of spiegeleisen. In section II., as an impure carbonate, we have clay ironstone, this consists of ferrous carbonate with about 15 per cent of clayey matter. The metallic content seldom exceeds 40 and is generally between 35 and 40 per cent. In section III. may be placed the Cleveland ironstone, which is a less pure form of clay ironstone; it contains about 33 per cent of metallic iron, and about 0.75 per cent of phosphorus. The gangue of this ore consists of clay combined with sufficient quantities of calcium and magnesium carbonates to make it practically self fluxing. This ore is found in large quantities and of uniform quality, containing about 33 per cent of metallic iron with about 0.75 of phosphorus. The pig produced usually contains about 1.6 per cent of phosphorus. The Blackband ironstones come under section IV, they are clay ironstones common in North Staffordshire and South Wales and also in Western Pennsylvania. They are intermixed with from 10 to 25 per cent of carbonaceous matter, which is sufficient to allow of calcination without the employment of any additional fuel. After calcination the residue contains from 50 to 70 per cent of metallic iron. One variety of this ore, obtained from North Staffordshire, is very rich in manganese and it used as a fettling in pudling furnaces. As an indication of what phosphoric content may be expected in pig iron smelted from certain ores the following table, published in "The Metallurgy of Iron," by Thos. Turner, is of interest:—

**Phosphorus Present in Pig Iron.**

| | Phosphorus per cent in the pig iron. |
|---|---|
| I.—From Non Phosphoric Ores. | |
| Swedish magnetities | 0.01—0.06 |
| Cumberland haematite | 0.04—0.06 |
| Spanish Haematite | 0.04—0.06 |
| Forest of Dean haematite | 0.07 |
| Lake Superior magnetities | 0.08 |
| II.—From moderately Phosphoric Ores. | |
| Purple Ore | 0.10 |
| Lake Superior magnetities | 0.15 |
| South Staffordshire clay ironstone | 0.40—0.60 |
| Leicestershire brown haematite | 0.60 |
| Scotch blackband | 0.60 |
| American red fossil (Alabama) | 0.65 |
| North Staffordshire blackband | 0.80—1.00 |
| III.—From Phosphoric Ores. | |
| Rhenish brown haematities | about 1.00 |
| Northamptonshire brown haematities | 1.00—1.50 |
| Derbyshire | 1.30—1.50 |
| Cleveland | 1.10—1.75 |
| Lake and bog ores | about 2.00 |
| Staffordshire Part Mine | 1.00—2.00 |
| Cinder pig | up to 3.50 |

It may be interesting to add the following figures to the above statement. Iron produced from the ores of Michipicoten and Sudbury districts in Canada

and from the Wabana ore in Newfoundland would approximate:

| | Phosphorus per cent in the pig iron. |
|---|---|
| Helen | 0.20 |
| Magpie (after roasting) | 0.02 |
| Moose Mountain concentrates | 0.20 |
| Wabana ore "Scotia" bed | 1.50 |

Many ores as extracted from the mines are unsuitable for immediate smelting in a blast furnace and must be submitted to a preliminary treatment. Washing is resorted to in some cases to remove the lighter earthy impurities. Material which is rich in sulphur, in the form of iron pyrites, is exposed to the weather for varying periods and during such time absorbs oxygen from the air. This converts the iron pyrites into ferrous sulphate, which is washed away by rain. Clay ironstones are frequently "weathered" by exposure to the atmosphere and thus, by the action of moisture and frosts, the shaly matter is disintegrated and falls away from the harder lumps of good ore. Magnetic ores containing phosphorus are crushed and passed through a magnetic concentrator. This machine divides the material into two streams, one being magnetic oxide of iron, while the other contains the major portion of the gangue and phosphoric acid. By this means it is possible to make iron of Bessemer quality from relatively inferior ores. Up to a very recent period it was usual to calcine most of the iron ores before smelting, but owing to the enormous increase of soft magnetite from the Lake Superior district this operation is not now nearly so common. It will, however, be necessary to outline the objects of calcination and these can be classed under three heads:—

I.—To remove as far as possible carbon dioxide, water, carbonaceous matter, and other volatile or combustible substances, to concentrate the ore so as to lessen the cost of transport, and to enable the process of reduction in the blast furnace to proceed more regularly.

II.—To eliminate as much sulphur as possible from the ore.

III.—To convert any ferrous oxide which may be present into ferric oxide, so as to prevent the formation of "scouring" slags due to imperfect reduction in the blast furnace.

Calcining methods vary according to the locality and the kind of ore to be treated. Brown haematites already contain ferric oxide and are calcined merely to eliminate water. The treatment usually consists of stacking the ore, more or less enclosed by rough walls, mixed with about 10 per cent of its weight of rough slack. Combustion being started at one end will work its way through the mass until the whole is dry, and the color of the ore has changed from brown to red. Blackband ores contain sufficient carbonaceous matter to enable calcining to be completed without additional fuel being added. During calcination the ore decreases considerably in volume owing to the elimination of the carbonaceous matter and of the carbon dioxide originally present in the ore. Clay ironstones and other carbonate ores are almost invariably calcined in kilns, as when so conducted the process is much more under control, whilst the cost of labor, fuel, and space is considerably lessened. A modern calciner of the Cleveland type will deal with about 1,000 tons of ore weekly and consumes about 1 cwt. of coal, in the form of rough slack, per ton of ore. Without any reservation we are quite satisfied that the near future will see the economic and satisfactory exploitation of the magnetic iron sands of Canada, and when this is achieved an enormous addition will be made to the available resources open to the makers of iron and steel. In the next article we shall deal with the conversion of ore into metallic iron by means of a blast furnace, noting particularly the chemical and physical changes incidental to the process.

## MONTREAL METALLURGICAL ASSOCIATION.

The next meeting of the Montreal Metallurgical Association will be held in the Physics Building, McGill University, on Wednesday the 13th March at 8.15 p.m. Mr. Walter A. Schmidt, General Manager of the Western Precipitation Company, will give an address on "Electrical Precipitation, its Application in Metallurgy and By-product Potash Manufacture.

## SHELL STEEL SPECIFICATIONS.

In our last issue mention was made of the chemical analysis called for in shell steel, and we are now informed, by Lieutenant Paterson, that the Inspection Department works to the British specification which reads:

| | |
|---|---|
| Carbon | — to 0.55% |
| Manganese | — to 0.40% |
| Silicon | — to 0.35% |
| Sulphur | — to 0.07% |
| Phosphorus | — to 0.07% |

Under special circumstances phosphorus to 0.08% is accepted. The Imperial Munitions Board calls for

Carbon from 0.40 to 0.55

because in their experience steel containing less than 0.40 frequently fails under physical test.

At a recent meeting held at Youngstown, Ohio, representatives of the U.S. Government, the Allies, and the various steel making concerns interested in Government contracts, considered whether it would be possible to secure some modifications in the specifications for shell steel. No decisive action was taken, but it is hoped certain changes will be effected. In Canada hundreds of thousands of tons of shell steel have been rejected and returned to the furnaces, owing to a slight divergence from the chemical specification. This divergence has in many cases been so small that it might well have been considered within the limit of laboratory error, but in the judgment of inspectors it was sufficient to justify rejection, and manufacturers had to submit to a heavy loss. It is certain from actual experiment, that the bulk of this slightly "off" material would have answered all physical tests. It is sincerely to be hoped that inspection departments and producers in the States will be able to evolve a scheme of acceptance, or rejection that will tend to lighten losses, increase net production, and reduce friction between those concerned.

It is stated that Newfoundland is busily engaged in making preparations to expedite the construction of wooden ships. The keel of one of 600 tons has just been laid down in a yard at Harbor Grace, and four others of 500 tons each are well advanced in the same yard.

# The Manufacture of Crucible Pots for Steel Melting

By CHARLES F. BRISTOL.

(General Superintendent Armstrong Whitworth of Canada, Ltd.)

This paper is to be presented at the Annual Meeting of the Canadian Mining Institute.

This is an industry, about which very little information has ever been published. In European countries the secrets and mysteries surrounding this trade have been handed down from father to son, consequently the expert pot-maker did very little "publishing." The famous Damascus steel, and some centuries later, the Toledo steels, were early examples of genuine crucible steels.

The first known steel made in a sort of clay crucible was called Wootz steel and was known first in India, later in Greece, as described by Aristotle, in a description of the process nearly 350 years before Christ. Archaeological discoveries indicate that a kind of crucible steel was known and made by the Chinese many centuries before the Indian product.

Crucibles used in the manufacture of steel are of two kinds, "clay" and "graphite." The clay crucible will be dealt with first, as in English practice it comes first in importance. The life of a crucible depends absolutely upon the human element, for in the hands of a capable furnace-man a clay or graphite crucible will last through twice as many heats as can be obtained from it by an inexperienced man. The average number of heats for a clay pot is three, though four and five heats can be obtained from some makes, when melting certain mixtures of pig iron and scrap, which only cut slightly into the sides of the pot at the slag line. The slag on a high speed steel usually cuts a deep ring in the clay pot at the slag line and consequently if 70 lbs. is the weight of the first mix, 65 lbs. would be the second, and 60 lbs. the third, so that the slag line shall be lower each time, but, with the alloys obtainable in these times, it is questionable if it pays to attempt a third heat in these pots, as they frequently collapse or burn through at the slag ring, with the subsequent loss of the molten steel before it can be teemed.

**Size of Crucibles.**—Clay crucibles are made of various sizes, but for melting steel, they are usually 16 to 18 inches high and about 9 to 11 inches diameter at the greatest girth.

**Materials Used.**—The clays used in England are china clay or kaolin, Stourbridge, Derby, Sheffield and Stannington clays, but in Canada, we use what we can get from England and make up the balance from mixtures of United States' and Canadian clays. Several very good grades of crucible clay are now offered by a large United States firm. Certain percentages of coke, burnt clay or ground-up pots are also added. The addition of ground or pulverized coke makes the pot more porous and permits more expansion and contraction, due to temperature variations without cracking. Another very important point is that the mix shall not be too "short," which means lacking in plasticity. A clay depends for its plasticity upon the amount of water of crystallization it contains.

**Typical analyses of clays used for crucible making.**

| | China. | Derby. | Stour-bridge. | Stann-ington. | New Brunsw'k. | Crucible | Bond T[1] |
|---|---|---|---|---|---|---|---|
| $SiO_2$ | 49.3 | 46.1 | 59.41 | 44.25 | 63.85 | 56.42 | 49.58 |
| $Al_2O_3$ | 37.2 | 32.81 | 26.28 | 33.46 | 22.10 | 30.24 | 35.02 |
| $Fe_2O_3$ | 0.4 | 2.00 | 1.91 | 2.64 | 2.20 | 2.20 | 1.99 |
| CaO | 0.15 | 0.7 | 0.53 | 0.55 | 0.32 | 0.34 | 0.49 |
| MgO | 0.48 | 0.29 | 0.64 | 0.9 | 0.21 | 0.86 | 0.35 |
| $H_2O$ | 11.27 | 16.8 | 10.45 | 16.22 | 3.12 | 8.64 | 10.50 |
| Alkali | 1.27 | 1.4 | 0.78 | 0.91 | 1.45 | 1.42 | 1.85 |

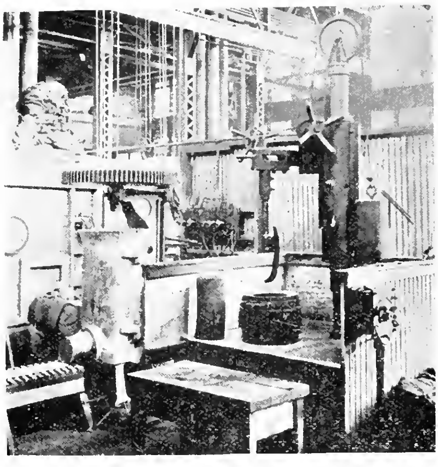


Fig. 1—Pug Mill (on left), Jigger and Jolly (on right).

**Mixing**:—The various clays and the "grog," are weighed out in their proper proportions and then riddled into the shallow soaking pan. This riddling helps to mix the various ingredients very thoroughly and prepares the clay for soaking. The soaking pan is generally of cast iron or steel plate about 8 ft. wide by 10 ft. long and 8 to 10 inches deep, either laid on the floor, or sunk in the floor, so that top edge of the pan is only one or two inches above the floor level.

**Soaking**:—The clay is spread out in an even layer over the bottom of the pan, then covered with water, and, finally a heavy damp cloth is stretched over the whole pan, to retain all the moisture in the clay. This cloth is kept above the clay by means of sticks laid across the pan, and is kept damp as long as the soaking is continued; generally twelve to eighteen hours.

* Read before the Montreal Metallurgical Association, October 17, 1917.

[1] "Bond T" is supplied by Harbison & Walker Refractories Co.

**Balling the Clay**:—As soon as the soaking is deemed sufficient, the clay is spaded and re-spaded for several hours, until it has a uniform consistency. It is now ready for balling. The old time pot-maker used to spread the clay in an even layer which was then "trodden" with the bare feet; the object being to tread the materials thoroughly together, and by squeezing all the air out of the mass, make it perfectly homogeneous. In England many potteries still follow this process, claiming that a superior crucible is made thereby, but the pug mill is used now for mixing or "balling" by the largest and most progressive companies, and if the clay is properly pugged there is no difference in the life of the pot so far as we have been able to observe.

**The Pug Mill**:—This consists of a metal cylinder placed vertically. A central shaft extending from end to end has attached to it a number of blades or "knives" arranged like the thread of a coarse screw, so that, as the shaft turns, the knives cut the clay, mix it, and force it downward through the cylinder to be re-cut and mixed by every succeeding blade with which it comes in contact. Finally the clay is forced out through the die at the bottom of the pug in a thick heavy column. The cylinder of clay is about eight inches in diameter and is cut off in lengths of about fifteen inches. In this manner a very homogeneous product is obtained, especially if the clay is passed through the mill several times. The shape and arrangement of the knives in the pug mill is highly important and varies slightly in different types of mills. The blades do not lie at right angles to the shaft, but are arranged in a helicoidal form so as to impart a downward motion to the clay. The presence of one or more knives fixed to the interior of the casing increases the output by preventing the rotation of the mass of clay. At the base of the vertical cylinder, which comprises the main body of the pug, a complete screw or helix is fixed horizontally. This does not mix the material but carries the clay forward with a greater force, which is needed to compress the clay and drive it through the round die.

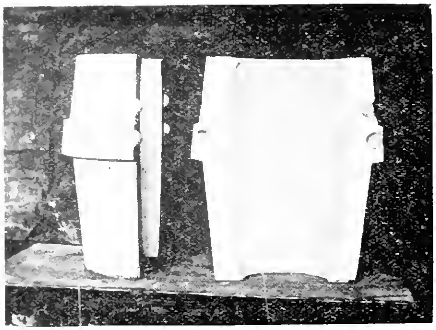


Fig. 2—Plaster of Paris Mould.

**Moulding Crucibles by Hand**:—Hand made crucibles for coke fired furnaces have a hole left in the bottom after the process of moulding. Hand moulding is done by means of a "plug" and a "flask." The flask has a loose bottom, with a hole in the centre, which allows the pin at the lower end of the plug to enter, and thus ensures the plug and flask being concentric. After the plug and flask have been well oiled, the ball of clay is dropped into the flask, and the plug inserted and worked into the clay by hand, until the latter has been forced about half way up the flask, The plug is then struck on the top with a heavy wooden maul until the clay is forced up level with the top of the flask. Then the plug is withdrawn, and the flask with the completely formed crucible inside is placed on a small post. This allows the flask to drop down, leaving the loose bottom with the crucible upon it, standing on the post. The mouth of the crucible is then pressed inward by what is called a "turning-in-dish." This lessens the possibility of spilling the charge, if the pot tips in the furnace, or during the teeming operation. This shape also gives the crucible greater strength and prevents the mouth of the pot from being chipped.

**Moulding crucibles in a press.**—Crucibles are often made by means of hydraulic presses or screw-presses, in which case the pots have solid bottoms. In Europe the hydraulic press is extensively used, while in England the screw-press is generally employed.

**Jiggers**:—Machines driven by power for making crucibles have increased greatly in number in recent years, showing that even the ancient art of crucible-making is endeavouring to keep up to the times; the skill of the individual being replaced by a machine, with a resulting increase of speed and decrease of cost. The best known machine is the "Jigger," which is an upright spindle carrying a split mould to form the outside of the article, and the "Jolly," which may be a piece of wood, cast iron, or steel, fixed to a radial arm in such a manner that when the jigger revolves, the "jolly" can be forced down into the ball of clay, forming a cavity, and, at the same time pressing the clay up the sides of the mould. This is the first step in the process of forming the pot. The "jolly" also has a horizontal travel at right angles to the axis of the pot, by means of a rack and pinion on the radial arm. The squeezing action caused by the "jolly" travelling at right angles to the axis of the pot forces the clay to the contour of the mould and the surplus clay is forced up above the top of the mould where it is cut off with a stiff wire, leaving a nice smooth top on the pot. In this way the bottom and walls of the pot are formed with great rapidity. The thickness of the bottom and walls are regulated by means of automatic stops on the vertical and horizontal rack and pinion feeds. The split mould is then removed from the "jigger," gently rocked, and then carefully opened up, leaving the finished crucible ready for drying. Great care must be taken in stripping the split mould

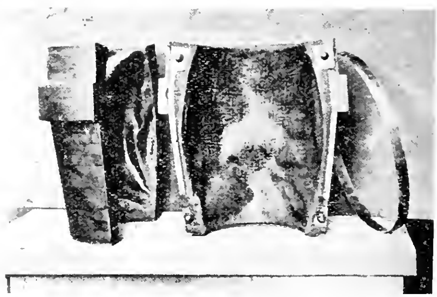


Fig. 3—Canvas Lined Wooden Mould.

from the crucible, as, if this is done rapidly or carelessly the crucible is sure to open up in the fire along the seam caused by the joint where the two halves of the mould fit together. If the crucible opens along this seam when in the fire, the whole charge of steel is lost in the bottom of the furnace and it is almost impossible to reclaim, if it happens to be high speed steel, as the bottom of the furnace is covered with coke breeze.

**Moulds for the "Jigger."**—These moulds are generally made of wood or plaster-of-paris and are split. Wooden moulds are suitable for clay crucibles as they strip quite easily, but graphite pots, being softer after moulding, do not strip well until they have stood a few hours, when the crucible shrinks away from the walls of the mould. Consequently, plaster-of-paris moulds are safer for graphite pots. In fact, they are better for clay pots as well, but plaster-of-paris moulds take up a lot of room, are expensive, and fewer pots can be produced in a day. Wooden moulds may be lined with canvas, silk or jute. The lining is well oiled, the halves of the mould are fitted together, and a metal band slipped around the halves, holds them together. The mould is then ready to be placed in the "Jigger" and to receive the ball of clay.

**Drying.**—The crucible, after being removed from the mould, must be carefully dried. In large plants they are placed on racks over a few steam pipes for a week, so that they may dry very gradually. If they are forced when green they are liable to crack. After a week or ten days, they are removed to another set of racks above steam coils. These racks are closed in, except at the top, to ensure a steady circulation of warm air. Two weeks more drying is sufficient, but the longer a pot is seasoned the better it stands the fire. In small plants the green crucibles are generally dried on racks around the furnace stacks. In Canada, the cold draughts in winter may cause the pots to "spawl" and crack so that special drying racks in a warm building are absolutely necessary.

**Annealing or Burning Crucibles.**—All crucibles must be annealed before use. Clay pots are annealed in either an annealing stove, semi-muffle, or muffle furnace. Sufficient clay pots for the day's melt, only, are annealed at one time, as the pots must be placed in the crucible furnace while still at a dull red. Ten to eighteen hours are generally required to bring them gradually up to the proper annealing temperature. If annealed too much or too little, the pots will either crack or spawl and will not last through a single heat.

Clay pots do not stand shipment and must be used in the plant, or very near the plant in which they are manufactured. They are transferred at the annealing temperature from the annealing furnace to the crucible furnace by means of tongs. The crucible furnace should be cooled down to the same temperature as the pots, and the pots may then be brought up gradually to the charging heat in the crucible furnace—otherwise, the pots will crack and spawl.

**Graphite Crucibles.**—Graphite enters into the composition of the great majority of crucibles that are used for melting steel in America. The raw materials used in the manufacture of graphite crucibles consist of some good pot clay and a pure variety of graphite. The Ceylon graphite, containing about 53 per cent carbon, is, on account of its leafy or foliated structure and its great compactness, more suitable for crucible making than the hard and amorphous varieties. In preparing Ceylon graphite for use it is broken up into small leaflets, which give to the crucible mix the desired structure of parallel strata. A crucible having this type of structure shows a tendency to develop cracks in burning and to obviate this, grog or crucible scraps are added. Quartz or pure sand in small amounts is also used in the mixture to cut down the shrinkage. The exact proportion of the various materials used will depend on the use the crucible is to be put to. An average composition is one part by weight of graphite to from one to three parts of clay and of grog or quartz. If the crucible is to be subjected to very severe conditions, a larger percentage of graphite is used, and this graphite must be free from its own dust. English graphite crucibles generally consist of about equal amounts of Stourbridge pot clay and Ceylon graphite. Several crucible manufacturers in England use two parts of Stourbridge clay, three parts of graphite and one part of crucible scraps; the latter being broken to about 1/8-inch size. The Duisburger crucibles, which are good for about thirteen melts of steel, consist of seven parts of a good stoneware clay, four parts of ground graphite and one part of grog screened through a 20 mesh screen. American graphite crucibles are generally made from Ticonderoga graphite mixed with Ceylon graphite, the material being ground in ball mills and mixed with small and varying amounts of kaolin, the amount varying with the use of the crucible. Ten parts of this graphite-kaolin mixture are used with seven parts of a grog pot clay, and a small amount of charcoal is added to produce a porous body. Until the outbreak of the present war the clay used in the United States for making graphite crucibles was all imported from Germany, being known as the Klingenburg clay. Since then, the firms using graphite crucibles have experienced very serious trouble while experimenting with American clays.

The composition of crucibles for melting cast steel varies with the hardness of the metal. For hard steel the composition is approximately fifty-four parts of graphite, thirty-six parts of clay and ten parts of grog; for softer steel forty parts of graphite, thirty-eight parts of clay and twenty-two parts of grog. Another typical mixture contains fifty parts of graphite, forty-five parts of fire clay and five parts of sand. Crucibles of this mix, and holding sixty to seventy-five pounds of casting steel should be good for from six to eight melts.

In preparing these various mixtures the constituents are carefully weighed in the dry condition and then put into a suitable mixing machine, where water is added and the whole thoroughly mixed to a stiff dough. This mixture is then made up into good-sized blocks or balls and stored in a damp room for days and even weeks to develop plasticity and to give the mixture a uniform moisture content. Immediately before using this material, it is put into a pug mill, thoroughly worked and then forced through a die, issuing as a thick column which is then cut up into blocks of a size varying with the dimensions of the crucible into which it is to be made. The crucible is made in various ways, which have been described above, such as pressing, turning and jiggering; the latter method being largely used in America.

The problems involved in drying the crucible vary, of course, with its size. The drying is usually accomplished in rooms which are warmed by heat generated for the purpose or by waste heat. It is not uncommon to employ two rooms, one warm damp compartment at

a temperature of about 65 degrees F., and another, the drying room proper, having a temperature of about 130 degrees F.

Owing to the presence of carbon (graphite) the annealing or burning of the crucible must be so managed that combustion of this element shall not take place. For this reason, the crucibles are placed either in saggers or in muffle furnaces for burning. The saggers may be partly filled with powdered coke to bring about reducing conditions, or this atmosphere can be obtained by firing with strongly reducing fires. The temperature of burning is cone 0.018 equal to about 1310° F. If a small amount of graphite is burned from the surface, thereby producing a gray or reddish appearance, it is customary to rub the crucible down with powdered graphite to restore to it the black glossy texture which the trade seems to prefer, although obviously the quality of the crucible is practically unchanged. Some manufacturers paint the exterior surface instead of rubbing down with graphite, claiming that the coating of paint excludes the moisture better. Graphite crucibles should be heated gently before using in order to drive out any moisture absorbed during shipment.

**Annealing Bare**:—Place the crucible in a muffle furnace and bring the heat up very slowly so that at the end of 24 hours the pots will have attained a dull red heat (about 1,300 degrees F.) then maintain that temperature for another six hours, and permit them to cool gradually in the furnace.

**Annealing in Saggers**:—Increase the heat of the muffle furnace gradually allowing about 36 hours for the temperature to reach 1,500 degrees F., then maintain the furnaces at that temperature for 42 hours, thereafter permitting the furnace to cool gradually.

In conclusion, it should be stated that the methods herein described for making crucibles are by no means the only ones available, as each crucible maker may find it necessary to evolve a different treatment for different clays, or mixtures.

# The Fuels of Canada

By B. F. HAANEL,

Chief of Division of Fuels and Testing Department of Mines.

Read at the Annual Meeting of the Canadian Society of Civil Engineers.

If the violent rupture of the peaceful conditions existing some four years ago had not occurred, it is very doubtful whether the subject of fuels would attract any special attention to-day, unless, perhaps, a discussion of such a subject disclosed new fields for profitable exploitation. To-day, however, the attention of the people of this country is forcibly centered on this very subject; because we are realizing, perhaps for the first time, our dependence, to so large an extent, on the United States for this essential commodity, and, further, are beginning to understand that our supply of fuels from that country may be cut off at any time.

In the past, and up to the present, we have been depending largely on fuels mined and prepared for the market by labour over which we have absolutely no control. As a consequence, we are at the mercy of foreign strikes and industrial disorganization, and either one or both of these are liable to occur.

A strike of coal miners, or a railroad strike in the United States would affect Canada more seriously in certain respects than the States, since in Canada we would not have the advantage of accumulated reserves which the United States would be certain to have in normal times.

But, there is even a more important factor which we must consider, viz.: the necessity which may occur for the United States to keep her fuels within her own country. Such a situation may not arise for some time, but the indications are that we may have to meet such an emergency in the near future.

Canada, to-day, is facing a fuel situation of great gravity; a situation which has not been created by any special conditions in this country, but by those obtaining in the neighbouring country. The United States is suffering from a shortage of fuels as a result of the withdrawal of skilled labour from the coal mines to other occupations, and, perhaps more directly, to the abnormal demand on the transportation facilities of that country for the carrying of material directly connected with the conduct of the war.

We are not wholly dependent on the United States for our fuel supply, but we are dependent to the extent of 55 per cent of our total coal requirements and 98½ per cent of our crude and refined oil products. Large and important sections of Canada, moreover, are almost wholly dependent on imported coal for house-heating purposes. This is a matter for grave reflection, since in a country such as ours, where artificial heat must be supplied during eight months of the year for the sole purpose of maintaining life, a continuous and dependable supply of fuel is absolutely essential.

The fuel situation existing in Canada to-day is due to the ease with which fuels of all kinds, suitable for every requirement, were imported from the United States, and to the apathy displayed towards the exploitation of certain of our own fuel resources by the public at large.

We have not exploited our fuel resources, with the exception of wood, on an extravagant scale, but, on the contrary, we have been culpably neglectful of these vast stores of energy, insofar as we have failed to provide for the future by learning how to use our low grade fuels, on which at no distant time we shall have to depend. The result of this neglect to improve our position and render ourselves independent, as far as possible, will be great suffering to the people of Canada, in the event of a stoppage of fuel supplies from the United States, if we do not, at once, take steps to render our own fuel resources available for our own needs.

The present unsatisfactory—indeed alarming—situation can only be improved by a determined and energetic exploitation and utilization of our own vast fuel resources.

I am prepared to show that Canada does possess abundant supplies of fuels, favourably situated and that these can be exploited in such a manner as to render her much less dependent on, if not entirely independent of, foreign sources for her fuel supply.

Before enquiring into our fuel possibilities, it is necessary to state and analyse our annual fuel requirements.

### Canada's Fuel Requirements.

The total fuel requirements of this country during the year 1916 amounted to nearly 30,000,000 tons of coal; 299,426,121 imperial gallons of crude and refined oil products, and firewood valued approximately at $60,000,000.

The railways burned 9,000,000 tons of bituminous coal; 7,000,000 tons were probably required for the purpose of generating power, and a large quantity was used for making retort or town gas, heating large buildings, and the manufacture of coke. Over 4,000,000 tons of anthracite were burned in domestic and other heating plants, and, to some extent, were used for industrial purposes. In normal times, practically the entire imports of anthracite coal are used for heating purposes.

Compared with her annual requirements, Canada's production of fuels for the same period amounted to 14,483,395 tons of bituminous coal, of which 2,135,-359 tons were exported; 6,934,288 imperial gallons of crude oil, and wood fuel to the value of $60,000,000. To meet our own needs, therefore, it was necessary to import 17,580,603 tons of coal, and 292,426,121 imperial gallons of crude and refined oil products.

Of this quantity of oil, approximately 50,000,000 gallons were used on the railroads; 30,000,000 gallons for steamships, and the remainder, 210,000,000 gallons, was used for lighting and heating, in the form of kerosene and, to a large extent, in the form of gasolene, for power purposes.

This is a general statement of the extent of our dependency on the United States for these essential commodities.

An analysis of our fuel resources, their location and extent, will reveal the reason for the necessity of these excessive imports.

### The Fuel Resources of Canada.

The fuel resources of Canada exist in the vast coal fields of the extreme eastern and western portions of Canada; the lignite fields of the western provinces; the natural gas fields of western Canada, and the province of Ontario; the petroleum fields of Ontario; the oil shades of New Brunswick, Nova Scotia, and elsewhere; the standing forests, and, last, but not by any means least important, the great areas of peat bogs. This is a truly formidable array of resources. Now, let us enquire into their extent, quality, and location, since these are the most important factors concerning their exploitation.

The following is an estimate of the actual coal reserves of Canada, based on actual thickness and known extent. The location and approximate classification of the coals are also designated.

| | Million Tons. | |
|---|---|---|
| Nova Scotia. | 2,137 | bituminous coal, and |
| | 50 | cannel coal. |
| Saskatchewan. | 2,412 | lignite. |
| Alberta. | 382,500 | lignitic or sub-bituminous coal. |
| | 1,197 | low carbon bituminous coal. |
| | 2,026 | anthracitic and bituminous coal. |
| | 669 | semi-anthracite coal. |
| Brit. Columbia. | 23,653 | semi-anthracite and bituminous coal. |
| | 118 | low carbon bituminous coal. |
| | 60 | lignite. |

In addition to these admittedly great coal reserves, we have in this country 37,00 square miles covered with peat bogs. The total estimated tonnage of fuel represented in this area is 28,000 million tons of 25 per cent moisture peat fuel, equivalent, on the basis of actual heating value, to about 16,000 million tons of good coal. Of this total area, however, only a portion is favourably situated with respect to economic development. 12,000 square miles of peat bogs are distributed throughout the central provinces: Manitoba, Ontario, Quebec, and New Brunswick, and the estimated tonnage of peat in this area is 16,000 million tons, equivalent, on the basis of actual heating value, to 9,000 million tons of coal.

No estimate can be made of the forests of Canada which are available for firewood, and natural gas has a special value only in those districts which can be economically served with this fuel. Natural gas is of great value when it can be obtained in large quantities in well populated and industrial communities, but it possesses the disadvantage of being an uncertain source of heat.

Of petroleum, all that I shall say, at the present time, is that Canada is manifestly not a petroleum producing country.

The principal fuel resources, then, which we have to consider are the bituminous and anthracite coals, the lignites, and peat. Oil shales and other sources of oils will be considered later.

The statement of the distribution of our fuel resources discloses the fact, that the true coals are situated in the extreme east and west, and the western part of Alberta; the lignite coals are situated in the provinces of Alberta and Saskatchewan, but lying between the limits of these deposits is a great stretch of territory devoid of coal measure of economic value. The 12,000 square miles of peat bogs are situated in this area.

The country naturally lends itself to a division into four parts or districts, and each district has an abundance of fuel peculiar to its own area. The first district embraces that portion of western Canada which can be economically supplied with bituminous and anthracite coals; the second district, that area which can be supplied with lignite; the fourth area, that portion of Canada which can enjoy the full advantages of Nova Scotia coal. The third district cannot be economically supplied with any of the above coals. This area must either render itself independent of foreign fuel sources, by developing and utilizing its excellent peat bogs, or remain, to a large extent, dependent on the United States. A large portion of the province of Ontario is principally affected in this manner.

To supply certain of these areas with fuel of the desired quantity and of a quality suitable for various purposes, constitutes a problem which must be satisfactorily solved before we can improve our fuel situation.

The bituminous coals of Canada are similar to those of the United States, and include large quantities of excellent coking coal. Their utilization for general industrial purposes presents no difficulties whatever, but for domestic purposes bituminous coal, in its raw state, is far inferior to anthracite, which is the fuel almost entirely used for this purpose in Canada. A most excellent fuel, practically the equal of anthracite, can, however, be produced from bituminous coal by a special process consisting of carbonization at low temperature and briquetting. This process is in actual operation to-day turning out briquettes of this description, entirely satisfactory for domestic purposes.

With lignite and peat, however, the situation is totally different. In their raw state, peat and a large portion of the lignite are not suitable for use. These fuels must be submitted to some preliminary treatment before they can be utilized for general fuel purposes.

When the peat deposits of the central provinces, and the lignites of Saskatchewan and Alberta are rendered into forms convenient and suitable for domestic and industrial purposes, the fuel situation, so far as Canada is concerned, will have been greatly improved.

Before treating these two fuels in detail, it is necessary to draw your attention to the fact that the transcontinental railways traversing the western provinces are prohibited by an order of the Railway Commission from burning lignite in the locomotives during the summer months. These railways, on their west-bound trips, are consequently compelled to burn imported coal to that point in the western coal fields where they can again replenish their tenders with native bituminous coal. The same thing takes place on that portion of the Eastbound trip traversing the province of Ontario.

Apart from this order issued by the Railway Commission, the railways would much prefer to haul and burn imported coal, inasmuch as lignites—at least certain of them—are not suitable for locomotive use.

The railways of Ontario also are entirely dependent of imported coal.

### Preparation of Lignite and Peat for Economic Utilization.

The utilization of certain of the lignites for some purposes is possible without any subsequent treatment. With others, however, notably those of Saskatchewan, the lignites as mined are not suitable for use. This is due to the physical and chemical properties peculiar to this type of fuel.

Lignites usually contain large quantities of moisture, ranging from 16 to 35 per cent of the weight of the fuel, and the evaporation of this moisture, whether by natural or artificial agencies, results in the disintegration of the fuel. This disintegration, however, does not discontinue when the evaporation of the moisture is complete, but appears to go on indefinitely.

One more peculiarity must be mentioned, viz., the dangerous sparks emitted from the stacks or locomotives when lignite is burned. These sparks, when they emerge from the stack, burn with a small flame and this flame is not extinguished by its passage through the air, as is the case with bituminous coal or anthracite coal sparks but continues to burn after lighting on the ground. On account of this dangerous property, lignites cannot be safely burned in locomotives.

Lignite, unlike the true coals—bituminous and anthracite—lacks definite structure. (This term is employed in its physical sense). To this may be attributed the reason for the difficulty with which lignites submit to mechanical treatment.

The characteristics of lignites must be altered before they can be converted into a satisfactory fuel. Experiments on a commercial scale have demonstrated beyond doubt the fact that our lignites cannot be briquetted in the raw state with or without the addition of a binder. Briquettes made in his manner appear, on casual examination, to be entirely satisfactory, but when submitted to a water test, or when burned, they will invariably disintegrate.

The characteristics of a lignite are changed by carbonizing it at low temperature. During this process, the moisture and volatile matter are completely distilled off, and there remains in the retort a residue composed of practically pure carbon. This residue is then mixed with a suitable binder, and briquetted. In order to render this briquette water-proof, a second heat treatment, or baking, is necessary. A fuel entirely satisfactory in every way, waterproof, capable of resisting disintegration when exposed to the weather, standing rough handling without breaking, not emitting flaming sparks, and capable of maintaining its physical structure or shape under the action of heat until completely consumed, has been produced by such a process. In order to demonstrate that this process will solve the problem in connection with our western lignites, it is advisable to erect a commercial plant capable of producing one or two hundred tons of lignite briquettes per day. Such a plant would have to be equipped in such a manner as to allow of a certain amount of experimental work being performed, e.g., in connection with binders.

I am of the opinion that it would require only a comparatively small amount of money, i.e., compared with the immense value which the solution of this vitally important problem would be to the country—to successfully demonstrate that the lignites of the west could, by means of such a process, be converted into a fuel entirely satisfactory for domestic and industrial purposes.

The establishment of briquetting plants at strategic points throughout the lignite provinces of the west would very greatly help in reducing our dependency for fuels on other sources. While a domestic fuel is, of course, of first importance, lignite briquetting industries would prove also of great value to the railways traversing the lignite belts. It would even be within the realm of possibility to economically supply at least a portion of the province of Ontario with this class of fuel.

The only remaining low grade fuel to consider is peat.

### Peat Fuel.

The exploitation of our peat resources for the manufacture of a fuel does not involve any research work or experimentation. An economic process for the manufacture of raw peat into an excellent fuel suitable for domestic and, to some extent, industrial purposes, is in use to-day, and has been employed for many

years in the peat-using countries of Europe. There is a flourishing and extensive peat industry in several of the European countries, but, in Canada, a country possessed of magnificent peat resources, and dependent to so large an extent on foreign supplies of coal, no peat industry exists. This deplorable state of affairs is due to misdirected energy in connection with the many attempts made to manufacture a fuel from peat, and to a general lack of interest towards anything connected with "peat" by the influential men of Canada.

Whether or not a particular natural substance shall be exploited has usually been decided from a "profit" point of view. Peat, not holding out great prospects for fabulous profits, failed to attract the attention of the large capitalists and industrial men. The creation of a peat industry was, therefore, left to the mercy of a few earnest and honest men with insufficient capital to prosecute an undertaking of this kind to a successful issue, and to a few fakirs and otherwise unscrupulous promoters, whose sole aim and purpose was "to get away with the money" before being discovered. Without going into detail, it will suffice to say, that several attempts have been made and as many failures with loss of capital involved have been recorded; but the larger portion of the capital lost could have been saved and a flourishing peat industry long ago established, if the promoters had been advised by accredited engineers who understood their business. Instead, however, of profiting by the experience of European investigators—gained at great expense—money was expended in developing and trying out ideas which had long before been discarded as impracticable, and, in many cases, impossible, by the investigators and engineers of the peat-using countries of Europe. Not until the results of the investigations conducted by the Mines Branch of the Department of Mines concerning the economic methods employed for the manufacture of peat fuel in European countries were placed at the disposal of the public, were men with impractical ideas dissuaded from interesting people in their schemes. Men of this description are still found going from place to place in a vain endeavour to interest capital, but they are rapidly disappearing.

Not until the utilization of a natural substance is forced by absolute necessity, will the most sincere and earnest efforts be put forth to successfully and economically convert it into a usable product. It appears to me that the time is at hand when necessity will decide that we Canadians utilize our peat resources, and in the most efficient manner.

Peat, in its natural state, is generally associated with about nine times its weight of water. It is, therefore, evident that 1,800 pounds of water must be removed in order to recover 200 lbs. of solid matter. Moreover, this solid matter not only represents the combustible substance, but also the ash and mineral matter which is associated with the peat.

The separation of this large quantity of water, and the handling of so large a quantity of raw peat substance, in order to obtain a comparatively small quantity of combustible matter, represent the difficulties with which we are confronted when an attempt is made to manufacture peat into a fuel, on a commercial basis, and in a thoroughly economic manner.

The only economic process in existence to-day is that which employs the forces of Nature — the sun and the wind—for the removal of the moisture. The process employing these forces is called the "wet process," and the product obtained is termed "machine peat." This is the process which the Mines Branch, Department of Mines, demonstrated at the Government peat plan at Alfred, Ont.

We not only have the process for manufacturing peat fuel, but also sufficient detailed information concerning peat bogs of immediate importance, to make a good start in the formation of a peat industry.

During the period covering the past ten years, the Mines Branch has completely investigated and mapped 58 Canadian bogs, all of which are situated conveniently with respect to inhabited and industrial communities, and also well situated with respect to railway and other transportation facilities. The investigations are conducted with a view to determining the principal and controlling characteristics of a bog, viz., its area, depth, quality at different depths, quantity in tons, and, in general, its suitability for any particular purpose. The area examined in detail comprises 170,000 acres, and represents a quantity of standard peat fuel, i.e., fuel containing 25 per cent moisture, estimated at 120,000,000 tons. Seven bogs conveniently situated with respect to Toronto could supply that city with 26,500,000 tons of fuel, and seven bogs in easy reach of Montreal could supply 23,500,000 tons of fuel. Excellent bogs are likewise, conveniently situated with respect to thickly inhabited communities, in Nova Scotia, New Brunswick, and other parts of Canada. This completes our inventory of the solid fuels. In regard to oil, we are not so favourably situated.

**Sources of Oil.**

The oil fields of Ontario, the oil shales of New Brunswick, Nova Scotia and elsewhere and the bituminous coals and lignites constitute the only economic sources of oil known to exist at the present time. Energetic and intelligent prospecting directed by able petroleum geologists may disclose new oil fields of economic importance. This, however, must be accomplished before the above statement of our oil resources can be modified.

The productivity of the oil fields of Ontario is decreasing at so rapid a rate that it will be comparatively only a short time before they will cease to be a source of oil.

The oil shales of New Brunswick and Nova Scotia are, on the other hand, a most valuable source of oil. They are of large extent and rich in oil. The average oil content of a large number of samples representing various portions of the New Brunswick shale deposits is from 35 to 40 imperial gallons per ton and if these samples are representative of the entire deposits, the total quantity of oil contained in these shales is very large.

Our bituminous coals and lignites also may become important sources of oil. The yields of benzol and tar from one ton of bituminous coal when coked in a byproduct recovery oven are respectively 1½ and 5 gallons. The maximum yield of oil which might be expected when lignites are distilled solely for this purpose is probably not more than 3 per cent of the weight of the fuel distilled. This figure may be subject to change; but the results of the work so far completed by the Mines Branch in connection with an investiga-

tion concerning the value of lignites as a source of oil do not indicate that a higher yield can be expected.

The total quantity of coal coked in Canada during 1915 was 1,856,393 tons, and if this quantity were coked in by-product coke ovens the yields of benzol and tar would be 2,800,000 and 9,000,000 gallons respectively. This yield of benzol could be further increased by distilling the tar recovered. The maximum quantity of benzol which could be recovered from the above quantity of coal is about 3,712,786 gallons.

The yield of light and heavy oils from 1 ton of bituminous coal is considerably increased when this coal is carbonized at low temperature.

Our oil requirements, as stated before, were, in 1916, nearly 300,000,000 imperial gallons, while our domestic production was less than 7,000,000 gallons. A small quantity of benzol also was recovered in the by-product coke ovens operated during that year. In order, therefore, to produce sufficient oil to equal our imports of this commodity, we would have to distill an enormous quantity of coal and lignite, or oil shales, or both. The production of 300,000,000 gallons of oil from lignite wuld necessitate the distillatin of about 30,000,000 tons of this fuel. This is manifestly impracticeable.

As far as the oil shales are concerned, their distillation on a very large scale is not only entirely practicable, but very desirable. Large plants for the distillation of oil shale are in continuous operation in Scotland, and such plants were in operation in France prior to the war. Our shales are in no sense inferior to those of Scotland and could be exploited as easily and as profitably. No sound reason, therefore, exists for allowing this valuable source of oil to lie undeveloped.

Our domestic production of oil cannot be increased without great effort, and the expenditure of considerable money, but provision must be made, and immediately, to provide against the time, not far distant, when the United States will be compelled to cease exporti g her crude and refined oil products.

This will be forcibly brought into evidence by the following statement regarding the present status and future outlook of the oil industry in the United States. The production of oil, from 1859 to the year 1915, was 3,616,561,244 barrels, of 43 gallons to the barrel, and the possible future production is estimated at 7,629,000,000 barrels. This estimate was prepared for Senate Document 310, and was made by 30 prominent petroleum geologists of the United States Geological Survey. The United States, up to the year 1915, had exhausted 32 per cent of her possible petroleum resources. If the present annual production is maintained, but not increased, her total crude oil supplies will be exhausted in less than 30 years. But, if the present rate of increase of production is maintained, total exhaustion will occur in a much shorter time.

It is apparent, then, that we will not be allowed to enjoy the advantages of the oil resources of the United States for a great while longer.

We can scarcely hope, for some time to come, to produce oil on a scale comparable with our demands—but we can appreciably reduce the quantity which must be imported and when oil can no longer be imported we will simply have to reduce our requirements or else find a substitute.

Our total oil production from all sources might probably be increased to 120,000,000 gallons; by erecting oil shale distillation plants in New Brunswick with a combined capacity of 100,000,000 gallons and by increasing the quantity of coal coked in by-product ovens or by carbonizing large quantities of bituminous coal at low temperature and briquetting the carbonized residue.

The low temperature carbonization and briquetting of Nova Scotia coal either in Nova Scotia or at some centre of distribution favourably situated with respect to water transportation, as Montreal for example, would not only appreciably increase our production of oils, but would also be the means of supplying, for domestic purposes, a coal equal in many respects to anthracite. The fuel situation of some parts, at least, of Ontario might, in this manner, be much improved.

If this idea were carried out, our oil production would be:—

| | |
|---|---|
| From oil shales . . . . . . . . . . . . . . . . | 100,000,000 gals. |
| " coke ovens and low temp. carbonization .. . . . . . . . . | 14,000,000 gals. |
| " Ont. petroleum fields...... | 6,000,000 gals. |
| | 120,000,000 gals. |

This completes the survey of our fuel resources and our fuel situation as it exists to-day. The fuel situation of the future will depend on the efforts we make to render our own fuel supplies available for utilization by the people.

**Economic Utilization of Our Fuels.**

I desire now to deal with the methods to be employed for the utilization of fuels in general, in order to convert the maximum of their heat energy into usable forms of energy, and to recover the maximum of the valuable chemical compounds which can be obtained from the solid fuels.

All of the solid fuels contain the element nitrogen, some to a very large extent, and this is the basic element of a most important chemical compound—ammonium sulphate. In normal times this substance is used very extensively for agricultural purposes, in order to restore to the exhausted wheat fields and other agricultural lands the essential nitrogen which has been removed, almost to exhaustion in certain instances, by the repeated raising of the same crops.

The necessity for employing such a fertilizer on our western wheat fields may not be apparent to everyone, because of the large increase in our wheat production reported from year to year. This is directly due to the large crops realized from the new virgin fields which are put under cultivation each year. The average yield per acre of the older wheat fields, however, is rapidly decreasing, and if their production is to be maintained or increased an artificial fertilizer will have to be employed.

This fertilizer is, however, in great demand in other countries, and its recovery in Canada and sale to other countries would, in many cases, prove to be a profitable venture.

The solid fuels are burned on a large and continually increasing scale for the production of power, town or retort gas, for the manufacture of metallurgical coke, and for general heating purposes.

The employment of the by-product recovery coke oven for the manufacture of metallurgical coke is

taking place on a large and rapidly increasing scale in the United States, and Canada is now employing such ovens to considerable extent. The manufacture of coke in by-product ovens is attended with the recovery of ammonia and the oils previously referred to. The entire quantity of coal used for coke and gas making should be utilized according to this method.

Power, other than hydro-electric, can be produced from the solid fuels in two principal ways: through the media of, first, the steam generator, and steam engine; second, the gas producer and gas engine.

When the energy of coal is converted into useful work by the first method, all valuable by-products are forever lost. When the second method is employed, and the producer is of the by-product-recovery type, it is possible to realize a maximum recovery of the nitrogen content of the fuel. The thermal efficiency obtainable with the latter is also considerably higher than can be realized with the steam power plant.

The producer gas by-product recovery plant is eminently suitable for the production of a power and industrial gas, and the field of its application might be extended to include the supply of gas for certain domestic purposes, e.g., general heating. Such a gas possesses the advantage of low cost, inasmuch as the plant can be situated at or near the source of fuel. Moreover, the cost of operating the plant can be appreciably reduced through the sale of the by-products and this results in a further reduction of the cost of the gas per 1000 cu. ft., if the production of gas is the main purpose.

We, however, possess sources of fuels especially high in nitrogen, viz., the peat bogs. The average nitrogen content of all the peat bogs so far examined is high—but there are a few notable peat bogs of large extent, containing fuel of excellent quality, in which the nitrogen content is very high. The fuel of such bogs should unquestionably be utilized in by-product recovery producer gas plants, for the production of power or a power, industrial, and domestic gas. The bogs referred to and described in detail in Mines Branch Report 299, are favourably situated with regard to populated communities and industrial centres.

Some of our fuels are especially valuable for purposes for which no other fuel can be substituted. This is especially the case in the coking variety of bituminous coals, and these fuels, at the present time, are being used indiscriminately for all purposes, notwithstanding the fact that the coking coals are invaluable for many metallurgical purposes and cannot be replaced, by any means known to-day, with non-coking coal. A coking coal should, therefore, never be used for any purpose for which a non-coking coal will be entirely suitable.

The quantity of coke produced in Canada to-day is small, and the necessity for conserving this class of coal may not be apparent. The great demand, however, for metallurgical coke in the United States and the probable depletion in the not far distant future of the supplies of this fuel in that country will, in time, make our deposits of coking coal of special value. When that time arrives, we shall have an excellent commodity for purposes of barter, if we now take steps to conserve our supplies.

The problems associated with the distribution of fuel to the various parts of Canada are somewhat complicated, owing to the distribution of its population. In order to supply heat and power in the most economical manner and at the lowest cost to a population so widely scattered, the most rigid economy must be installed. The added cost to a fuel consequent on large rail haulage and local distribution can be very materially reduced by centralizing heating and power plants.

The populated sections of the country should be carefully studied with a view to its logical division into sections, each of which could be economically supplied with heat and power by one central heating or power plant. If this were carefully followed out, very marked economy would result in both the use of the fuel and its cost to consumer. The difficulties entailed in the distribution of the required fuel for such communities would, at the same time, be very largely overcome.

Many of our industrial plants have been located without any regard to the source of power or fuel on which they depend. Such industries, wherever it is possible to do so, should be moved to a locality which can be economically served with hydro-electric energy or electric energy generated in a large central plant, and industrial sites in general should be set aside for the location of all future industries.

It is evident that our fuels cannot be used indiscriminately and without the exercise of some degree of intelligence. We must not only meet all our own fuel requirements and place the people of this country in such position that they will not need to worry about a possible coal famine, but we must, at the same time, utilize our fuels in the most advantageous and economic manner. Great as our fuel sources are, we must practise conservation. Only by doing this do nations become strong and powerful.

The fuel situation of Canada, as I view it, is not a gloomy or discouraging one, for we are endowed with fuel deposits on a magnificent scale. All that is necessary now is that their proper exploitation and economic use be assured.

It will, therefore, be the duty of the Engineering Societies represented by your Society and others to produce the necessary and unremitting pressure upon the proper authorities to give effect to your recommendations for the betterment of our fuel situation, so that Canada may be, for years to come, relieved from the ever-recurring anxiety of where the next year's fuel supply is to come from.

You can readily understand that the task before you, as Engineers, is a difficult one, but one of the greatest possible importance, for the habitability of certain now populated sections of Canada depend upon the success of your efforts.

## IRON OXIDE IN MOLDING SAND.

In "The Foundry" for January, "Iron Oxide—Its Effect on Molding Sand," forms the subject of a paper by W. R. Beau. This is too exhaustive to be more than mentioned here, but the author attributes many foundry troubles to the presence of iron oxide in the sand. At a later date we shall publish articles dealing with foundry sands, their composition, mixtures, and various functions, dealing more particularly with methods for reclaiming the same, and the artificial replacing of alumina.

# Opportunities for the Establishment of an Iron and Steel Industry in British Columbia*

By ROBERT T. HEDLEY.

It may be observed that we have at present no iron and steel industry in British Columbia, as it is confined to small undertakings which depend wholly on scrap for their source of supply. It is said that we are not yet ready for such an industry; that our market is too limited, that our coal is not sufficiently developed at the Coast and is of inferior quality and too costly to make a suitable metallurgical coke at reasonable price; that the conditions prevailing in our labor market are such as to offer a serious handicap to economic work; and, finally, that we have no hematites as yet available to mix with the prevailing magnetites of the coast. Further it is believed that electric power is not obtainable at such cost as to render electric smelting for pig iron a commercial success at normal prices.

All this is rank pessimism and if persisted in will leave the Province a laggard in the march of progress.

**Market.**—Without going into figures on this subject, let us admit that the market for products of iron and steel (especially if limited to such as may be produced in a plant of modest rolling capacity) is small; nevertheless it is increasing, and surely it may be extended greatly in the time of great industrial activity that is sure to follow the war. Let us suppose that a beginning be made with an economic unit for blast furnace production of pig, open hearth furnaces for steel, and a rolling mill capable of producing the common sizes of bar, light rail, etc., is it not highly probable, nay, sure, that a profitable market will readily absorb any surplus if offered in the shape of steel billets.

**Coal.**—Opinions to the contrary notwithstanding my belief is firm that certain coal from seams of the Vancouver Island collieries, properly selected or washed, and coked in by-product ovens, will produce a superior metallurgical coke. As to cost there is a lack of data on which to estimate closely. The Canadian collieries are to-day coking their small coal in beehive ovens and supplying the Granby smelter at Anyox with about 3,000 tons per month at an approximate cost of $6.00 per ton. The management states that this absorbs all their small coal, and a further supply only be made by using lump, at a cost of $7.00 per ton. By-product coke may be produced at a substantially lower cost than beehive coke, using coal at the same price. Further, coal can undoubtedly be mined more cheaply on the Island. Estimates have been made that by-product coke can be produced at a cost of $4.50 per ton at the ovens—and this without taking into account the value of the gases and other by-products. Surely this question is worthy of closer investigation than it has hitherto received.

**Labor.**—Undoubtedly our labor conditions are adverse; but rightly handled, it is conceivable that this handicap may be overcome. Labor efficiency may be augmented by judicious management.

**Iron Ore.**—It is true that the ores of iron at the Coast are chiefly magnetites, that high grade hematites occur only remote from transportation, and that limonites are a somewhat doubtful asset. Magnetites are often of very superior quality, high in iron and very low in sulphur and phosphorus content. Other deposits however are contaminated by sulphur and copper, but the latter is not an unmixed evil, as it enables one to procure the desirable hematite, or its equivalent, at a low cost. At many points, notably at Birdsboro and at Lancaster, in Pennsylvania, and also in Norway and Sweden, low grade magnetites are crushed and magnetically separated, the resultant product being prepared for the blast furnace either by sintering or briquetting. The advocates of either process claim for their product a superiority over hematite for blast furnace work. Mr. B. G. Klugh,[1] of Birdsboro, Pa., referring to sinter says: "At all times the sinter has shown itself a superior and beneficial material for the blast furnace charge." Mr. Fred A. Jordan, when manager of the Moose Mountain iron mine, Ontario, said of his briquette which carried over 60 per cent. iron: "It has 30 per cent. voids and is made up of at least 90 per cent. hematite."

H. V. Hansell presented a very interesting paper on this subject to the Canadian Mining Institute.[2] The plant at Sellwood has not been in operation for the past two years, for the reason, that it was economically, though not metallurgically, a failure. The ore so treated carried but 36 per cent. iron, and the tailing about 7 per cent.

Three years ago, Mr. J. B. Tyrrel met at the Treadwell mine a Russian engineer who was having tested by the Grondal Co., of New York, a Russian ore, which carried 45 per cent. iron and 0.75 per cent. copper—and he anticipated highly successful treatment.

In this case the separation of ten tons would probably result in six tons magnetic and four tons non-magnetic. The latter by concentration would probably produce one ton of copper ore, making three tons waste. At Moose Mt., at least two tons were required to produce one ton of high grade briquette. Here, so far as my observation goes, one may start with a feed that will carry about 60 per cent. iron and 1.5 per cent. copper. He will therefore discard no tailing, but make two valuable products, a magnetic that will carry 67 per cent. to 68 per cent. iron and a non-magnetic with 7 per cent. to 9 per cent. copper and generally high in iron.

Three years ago I shipped to Tacoma 1,100 tons from Tassoo Harbor, Queen Charlotte Islands, an average analysis of which was as follows:

| | | |
|---|---|---|
| Iron | 62 % | Gold 0.02 oz. per ton. |
| Copper | 1.8 | Silver 0.4 oz. per ton. |
| Silica | 3.6 | |
| Lime | 1.0 | |
| Sulphur | 2.8 | |

Based on an analysis, one ten of ore may yield 1,600 pounds of magnetite containing say 68 per cent. iron

[1]Trans, A. I. M. E. Vol. XLIII, page 364.

[2]Trans. C.M.I. Vol. XVI., 1913.

*Paper read at annual meeting of C. M. I., March 1917.

and probably less than 0.2 per cent. copper. The non-magnetic 400 lb. of copper ore analyzing about

| | | |
|---|---|---|
| Iron | 38% | Gold 0.1 oz. per ton. |
| Copper | 8 | Silver 2.0 oz. per ton. |
| Silica | 16 | |
| Lime | 5 | |
| Sulphur | 12 | |

This latter sintered, will have a net value, for the 400 lb. of not less than $4.00, with copper at 15c per lb. and silver at 50c per oz.

The finely divided magnetite, sintered or briquetted, will be absolutely free from sulphur, will carry about 70 per cent iron as sinter or 67 per cent iron as briquette, and its physical character will command the very highest price in any iron ore market.

Such ore occurs at many points on the Coast, in apparently very large bodies, notably on Queen Charlotte Islands and Prince of Wales Island, as well as on Texada and Vancouver Islands. Generally its occurrence and location are so favorable that it may be mined, separated and sintered at a cost not to exceed $3.00 per ton—which means that 26 to 30 lb. copper per ton will pay all the expense, leaving our high grade artificial hematite 'on velvet.'

The conditions favouring the profitable establishment of an iron and steel industry on the Pacific Coast may be summarised, as follows: These are available:

| | |
|---|---|
| Magnetic iron ore of superior quality at a cost f.o.b. barge, per ton | $0.75 |
| Hematite second to none, f.o.b. barge, say. | .15 |
| Limestone of superior quality, f.o.b. barge | .50 |
| Coke probably available at less than.... ex by-products. | 5.00 |

As to labour, it can be trained; and as to a market it can be made and developed. The prospects in this respect are excellent.

As to electric smelting, without doubt any iron and steel enterprise should have an electric plant as an adjunct to produce high grade steels, but whether it will compete with the blast furnace in production of pig iron depends on the cost of power. The existing power companies if asked to quote a rate will doubtless give a tentative one of (say) one-half cent per kilowatt hour. On an exceptionally large contract, without long transmission, that figure might be cut in two, but probably a much lower figure would be requisite to ensure commercial success at normal prices. I offer for criticism an estimate on the cost of producing pig iron at a site selected for its fuel supply. The latter is specified because of the fact that iron ore supply may come from various points, and it is desirable that coke be manufactured at the plant in order that the gases may be utilized. I assume that equal parts of magnetite and hematite will make a suitable mixture:

| | |
|---|---|
| 0.8 tons magnetite | $ 0.80 |
| 0.8 tons hematite | 0.20 |
| 0.5 tons limestone | 0.25 |
| 1.25 tons coke at $6.00 | 7.50 |
| Freight on 2.1 tons | 2.10 |
| Labour | 2.00 |
| Interest and amortization | 1.00 |
| Power and sundry | 1.00 |
| | $14.85 |
| Less by-products, including gas | 2.00 |
| | $12.85 |

This estimate is based on the assumption that iron ore can be supplied at the low figure of $2.60 per ton of pig iron produced. Of this $1.60 represents freight charges, which may be reduced considerably. Added to the estimate of the cost of coke of $7.50, which is probably high, the cost of these two items is $10.10, or lower than at Pittsburgh, where the iron ore required per ton of pig iron costs about $8.50 laid down, and where the cost of coke is not less than $3.00 or a total of $11.50. Limestone in sufficient quantity to flux the class of charge specified would not cost 40 per cent of the figure given in the estimate.

## Discussion.

Dr. J. G. Davidson: In regard to Mr. Hedley's reference to the by-product coking of coals, I may say that during the past two years we have been trying experiments on the recovery of marketable by-products, such as creosote and pitch, during the coking of western coals; creosote being worth about fifteen cents a gallon. I am satisfied that the coke produced would be suitable for iron smelting, and consider that the Government should carry out experiments on the preparation of coke from 'Coast' coals in by-product ovens, and have the resulting coke tested in blast furnaces. We can also make charcoal of a fair quality from our western lumber, and at the same time secure valuable oils as a by-product.

Mr. E. A. Haggen: The problem to which Dr. Davidson referred, the production of suitable metallurgical coke from 'Coast' coals, has been solved by the manager of the Vancouver Gas Company, Mr. Keillor, who has been conducting experiments lately in the coking of Vancouver Island coal, with the result that, by the use of vertical retorts, he has obtained a coke of sufficient strength and freedom from deleterious substances, such as sulphur, to be adapted for metallurgical purposes such as iron smelting. The report of Mr. R. Lindeman, late of the Dominion Department of Mines, on the iron ores of the British Columbia coast was of a most satisfactory character so far as a supply of ores and cost of producing iron were concerned, but at the time the export was made there was not a sufficient market for the product. In 1909 and 1910, Eastern capitalists employed experts to investigate the problem of the manufacture of iron and steel in British Columbia, and their report was also satisfactory. The Vancouver Gas Company, however, did not believe it could supply metallurgical coke at less than $6 a ton. There is not at present any plant producing iron and steel on the entire Pacific coast of North and South America, with the exception of one small plant in California, which produces 12 to 15 tons of electric iron and steel a day. The Government should, therefore, be willing to assist in financing this industry, until it can be placed on a successful commercial basis, as a matter of national importance.

Mr. Nichol Thompson: Referring to the remarks of Dr. Davidson on the manufacturing of coke and the recovery of by-products, I have sent the analyses of our Vancouver Island and Nicola Valley coals as well as samples of the Nicola Valley coal, to by-product experts in England, and their reports prove these coals to be very high in by-products, which consist of light and heavy oils, creosote, tar and sulphate of ammonia. The value of the by-products was given as approximately $9 per ton, besides the coke, which would be valuable as a metallurgical coke, and would be exactly like what is costing $7 per ton in Sheffield. In fact the Nicola Valley coal is an ideal coal for distillation pur-

poses and should yield a very big return. Concerning Mr. Hedley's remarks on the sintering of magnetite, and thereby converting it into hematite, I confess I cannot quite understand how this is accomplished or what advantage is to be gained by doing so, even if it can be done. I don't think it matters how the iron exists, as long as the ore is physically and mechanically suited for the blast-furnace, and I believe we have magnetite ores in British Columbia that are particularly well suited for use in blast furnace without any considerable addition of softer ores. At one of the largest blast-furnace plants in England, they use principally the magnetite ores from Norway and Sweden with a mixture of spathic ores from Spain, and they manufacture all grades of pig iron from No. 1 to No. 4 or foundry iron. The following are typical analyses of these ores after drying:—

| | Fe. | $SiO_2$ | S. | P. | CaO | MgO | Mn |
|---|---|---|---|---|---|---|---|
| Highest Magnetite | 69.3 | 2.42 | .039 | .014 | .60 | .52 | .28 |
| Lowest Magnetite | 51.3 | 8.62 | .277 | .018 | 10.05 | 2.59 | .29 |
| Highest Spathic | 56.10 | 8.60 | .30 | .006 | 1.80 | 4.26 | 1.10 |
| Lowest Spathic | 47.90 | 14.90 | .286 | .027 | .80 | .37 | .76 |

Mr. Hedley's paper deals principally with magnetites containing copper, and of course those ores can only be made suitable for the blast furnace by magnetic concentration and briquetting. If briquette can be made hard enough and porous enough so that it can stand crushing strain and yet can be penetrated by the reducing gases in the blast furnace, that is all that is necessary, without any attempt being made to produce what Mr. Hedley calls artificial hematite. I have sent samples of our British Columbia magnetites to Sheffield and the report I got stated that high-grade tool steels could be made from these ores at a cost of $2 a ton lower than from the best Norway ores on account of their high iron content, and lack of impurities; the following is a complete analysis, made in England, of some of our British Columbia magnetites:

| | Per Cent. |
|---|---|
| Peroxide of iron | 64.35 |
| Protoxide of iron | 25.16 |
| Protoxide of manganese | 0.47 |
| Alumina | 0.96 |
| Lime | 1.00 |
| Magnesia | 3.89 |
| Silica and insoluble | 4.70 |
| Combined water and moisture | Nil |
| Arsenic and copper | Nil |
| Sulphuric acid | Trace |
| Phosphoric acid | Trace |
| | 100.53 |

| | | |
|---|---|---|
| Metallic iron | 64.05 per cent | This ore is of very good quality, indeed. |
| Sulphur | Slight trace | |
| Phosphorus | Slight trace | |

I believe the above to be a fair average quality of our British magnetites.

There is a much better market for iron ore and products of iron and steel on the Pacific coast than is generally supposed. At the present time 82,000 tons of steel shipping is being constructed between San Francisco and Vancouver, and another 40,000 tons is under consideration. In a paper read before the American Institute of Mining Engineers in 1916, Mr. C. C. Jones[3] estimated the market for iron and steel products on the Pacific coast to be 923,000 tons per annum, adding that "probably the aggregate (consumption) is more nearly double this estimate." In 1912 British Columbia imported 120,000 long tons of iron and steel, including more than 7,000 tons of pig iron; and there is a much bigger market to-day for mine steel than there was in 1912.

The production of pig iron in the United States has increased from 8,000,000 tons in 1896 to more than 37,000,000 tons in 1915. The total shipments of ore from the mines in 1915 exceeded 55,000,000 tons, and the increase in the production of pig iron amounted to 6,500,000 tons. In 1915, Great Britain imported from the United States 20,000 tons of steel billets valued at $11,000,000, and the returns for the month ending November 30, last, show that the unfilled orders of the United States Steel Corporation amounted to 11,058,541 tons, an increase of 1,043,282 tons over the preceding month. In 1912 Great Britain imported more than 6,000,000 tons of iron ore. The war will change the whole economic conditions of the Empire and if we are to maintain our position in the sun, and continue to be the foremost nation among the peoples of the earth, it can only be accomplishd by conserving our natural resources and manufacturing them within the Empire for the use of the Empire first. Germany's strength in the present war lays in the provinces of Alsace and Lorraine, stolen from France in 1871. Out of 28,607,000 tons of iron ore extracted from German territory in 1913, 21,135,000 tons came from the Province of Lorraine alone. It behooves us, therefore, to see that our resources of coal and iron are not allowed to fall into the hands of foreigners who may again, as Germany is doing to-day; use them against us for our destruction.

Prof. John M. Turnbull: There seems to be a very general feeling that the time is rapidly approaching when an iron and steel industry can be established on the coast of British Columbia. There are many difficulties, but these can be summed up under three heads. The first is the difficulty in regard to markets for the products, which I believe can be overcome, because the markets will tend to develop as fast as the industry. The second point is the difficulty of smelting our ores, and this may also be overcome. The third point, the difficulty in regard to ores, is therefore the problem of first importance. I believe there are large quantities of magnetite ore on this coast, but we have no definite knowledge as to what quantity can be obtained and its probable average grade and character. The Provincial Government should make a geological investigation to determine clearly the character of the deposits and thus help in predicting their future possibilities.

Dr. Edwin T. Hodge: The greatest need of the Province of British Columbia at the present time is an inventory of its natural resources, and this can be accomplished by means of an intensive geological survey. The question of markets is of great importance. It has been stated that we can find a market in England for a considerable part of our iron ores and iron billets but there are many deposits of iron ore both

[3] Trans. A. I. M. E. Vol. LIII., p. 308.

larger and nearer to England than any we have here. The highly developed magnetite deposits of Gellivare and Kiruna, in northern Sweden, are fully as rich and very much nearer than ours. The Wabana deposits on the north shore of Bell Island, Conception Bay, Newfoundland, are very extensive and are highly developed. Other deposits available to the British Islands are those of Minas Geraes, Brazil, with reserves estimated at 2,000,000,000 tons; the Mayari and the Daiquiti, of Cuba, both with great reserves; and the Bilboa deposits of Spain. Another market which has been suggested is China. That country may be backward in some ways, but in the investigation of its natural resources it is far ahead of British Columbia. Its geological survey has shown that extensive deposits of iron ore exist. Since iron ore is usually carried as ballast, and since the rule is for the vessels to travel east in ballast across the Pacific, is it not possible that the near future will see China exporting iron ore? We hardly have a right to discuss questions of manufacture until we have settled the far more important matters of occurrence, quantity, availability, and smelting suitability of our iron ores. But in view of the great ease of transportation from Vancouver to many Asiatic cities, we ought with a proper supply of cheap iron ore to become a manufacturing and distributing centre for iron machinery on other high grade products. It has been stated that several of our iron deposits are suitable for smelting, but as scarcely any of these have been opened we do not know to what geological type they belong and consequently cannot tell anything about their size or uniformity. We cannot, with advantage, build smelters until we have some definite idea as to tonnage nor can we do so until we know the type of ore we have to treat. I think you will admit all that with the limited geological examination which our iron ore deposits have received, except in a few instances, that we have only a faint idea as to the tonnage and no conception as to the type of ores which a smelter would have to treat. Many of these facts, I am sure you will grant, must be known before we can plan definitely for a smelter and before we can interest capital in the manufacture of iron from our ores. Before we can interest capital in our Province we must have a geological investigation of our mineral resources. Our Province is so vast that the geological work which has been done means but little. The Geological Survey of Canada can only put three geologists into the field in this Province each year. If we are to know our resources and develop them rationally, we must also have our own geological survey. Our mining prosperity is dependent upon a careful and systematic investigation of our resources along geological lines.

---

Shipbuilding on Vancouver Island and on the mainland is now proceeding at top speed. The Wallace yards in North Vancouver, in addition to the schooners, have been working on three steel steamships of the "War Dog" Type, one of which has already been launched. These ships cost about $650,000 each. A construction program involving $7,500,000 has been embarked upon by the Coughlan yards of Vancouver, which is now building six steel $1,250,000 vessels, one for Norwegian and five for British interests.—(Pacific Marine Review.)

## ELECTROLYTIC PICKLING OF STEEL.

In "Metallurgical and Chemical Engineering" for December 15th, 1917, page 713, is published the results of some experiments on this process by Messrs. Thompson and Dodson. Iron sheets, pipes, etc., that have been heated during the process of manufacture are coated with a scale of oxide. To remove this scale it is usual to immerse the sheets in a mixture of sulphuric acid and water, a process which results in the loss of some of the iron itself, as well as the scale, and involves a notable consumption of sulphuric acid.

The electrolytic process was proposed and patented by C. J. Reed, and consists in making the iron sheet the cathode of an electrolytic vat containing sulphuric acid and water, and having a lead anode. The application of an electric current has the effect of rendering the scale more readily soluble in the acid, and at the same time of preventing the action of the acid on the iron plate itself. It must be observed that the iron plate is not made the dissolving pole as would at first be thought, but that it is the cathode or depositing pole. Hydrogen is liberated here, protecting the iron and rendering the scale soluble. Particulars are not given as to how the process is carried out practically. In particular, electrical contact must be made to the sheet and it is not obvious how this can be done without leaving a part out of the liquid. Achilles, when an infant, was dipped by his mother in the river Styx, thus acquiring invulnerability, but his heel, by which she held him, escaped this beneficial treatment, and he ultimately succumbed by being wounded in the heel by an arrow. Further particulars of the process can be obtained by referring to a paper by Thompson and Mahlman, Transactions of the American Electro-Chemical Society, Vol. XXXI., p. 181, and one by Dr. Hering in the Metallurgical and Chemical Engineering, Vol. XIII., p. 785.

---

## ADVANTAGES OF HYDRO-ELECTRIC POWER.

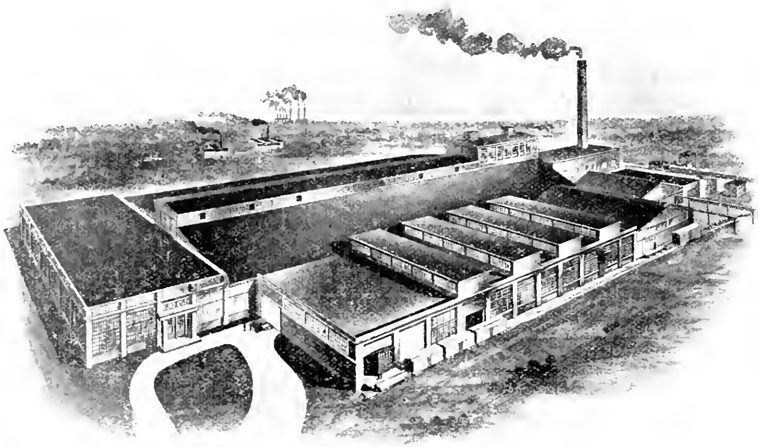
A fireless Monday has shown us in Canada how dependent we are on our coal supply, and in this connection it is interesting to compare the independence of those centres which derive their power, and to some extent even their heat, from electrical energy derived from water power.

In Metallurgical and Chemical Engineering, Feb. 15th, 1918, page 168, is a letter from the Sault Ste. Marie Civil and Commercial Association stating that all the large industrial plants at Sault Ste. Marie are running as usual under special exemption from the recent drastic fuel orders. These plants are operated by electric power from the rapids of the St. Mary's River. The Michigan Central Power Company and the Edison Sault Electric Power Company produce and distribute about forty thousand h.p. from these rapids which supply the Northwestern Leather Company, the Union Carbide Company and Sault Woolen Mills, beside many other plants.

From a conservation point of view it is desirable that our water powers should be developed as rapidly as possible in order to avoid depleting our coal supplies and, in addition, to render us as independent as possible of irregularities in this supply.

## A NEW APPRENTICESHIP SYSTEM.

When so many authorities are advocating intense development of technical education, more particularly as it benefits the artizan class, it will not be out of place to refer to efforts which are being made to secure, at least in part, the advantages of the old apprenticeship system. In the Lynn factory of the General Electric Company a special department, devoted exclusively to the education of apprentices, has been established. Specially qualified teachers are in charge, and from a very small beginning a comprehensive scheme has been built up. Every boy accepted for training must first successfully complete a trial period of two months, but the two months of time so served are considered a part of the whole apprenticeship period. This period has been set at four years for machinist and pattern-maker apprentices; foundry apprentices are required to serve two years, although they are strongly urged to continue during a third year of specialized foundry training. Those apprentices who are being trained for future efficient draftsmen and designers are required to spend an apprenticeship of three years, and must have had a complete high school education in order to be eligible. Upon starting for his trial period a boy is at once put to actual work either in the core room or on a machine and is closely watched by competent men, who, on account of their experience with thousands of other boys, are quick to detect, and capable to decide whether or not to continue the process of training the particular boy in the particular trade. If a boy shows satisfactory indications he is allowed to sign an agreement which is also counter-signed by his father, mother or guardian. This agreement stipulates the wages to be paid and is simple in form. Pattern maker apprentices commence with an initial rate of 10 cents per hour, or $5.40 per week, payable also during the trial period, and for the time spent in the classrooms. This rate is gradually increased until it reaches 16½ cents per hour during the fourth year of apprenticeship. These apprentices receive an appropriate diploma and a cash bonus of $100 upon satisfactory completion of their apprenticeship term. It is stated that the justification for the payment of wages for time spent in classrooms lies in the fact that apprentices are required to go into the classrooms for one hour and a half every day except Saturdays, and it would be unwise to deprive apprentices of any money which they could otherwise earn for themselves if they would remain all the time in the foundry, machine shop or pattern shop. From a very small commencement made about eleven years ago the system has grown until it now embraces departments for the special training of boys for the following trades: Tool makers, pattern makers, core makers, brass moulders, winders, induction motor test men, etc., etc. It is generally accepted that the many thousands of dollars spent annually in this way are more than repaid by the greater efficiency of the trained boys. Neglect on the part of educational authorities and employers has been responsible for the shortage of thoroughly trained and skilled artizans and it is to be hoped that a widening out and general acceptance of this scheme or one modified to suit local requirements, will do much towards improving the condition. The rapid development of machines, appliances and processes requires a higher standard of skill upon the part of the mechanics, and only by some sort of organised training can such a demand be satisfactorily met.



Plant of the Canadian Drawn Steel Company, Hamilton.

## THE MATHEWS GRAVITY PIG IRON CONVEYOR.

Canadian Mathews Gravity Carrier Co., Ltd., Toronto, have given us the following information regarding their Pig Iron Conveyor:

Construction—Units are 12 inches wide and six feet long, equipped with universal couplings. Rollers are cut from 11-gauge hot-rolled steel tubing, fitted with heavy, case-hardened ball-bearings of the improved detachable type. These rollers are $3\frac{1}{4}''$ in diameter and are assembled three and one-half inches from center to center, leaving $\frac{1}{8}''$ clearance between. Frames are constructed entirely of steel, rigidly braced to withstand hard usage. Roller axles run clear through and are held in side frame rails by means of lock bars. Removal of these lock bars gives access to any roller in a unit, rendering it convenient to replace entire rollers or bearings as the case may be.

Scope—Any number of units may be assembled in straight runs, or a ninety degree or forty-five degree curve introduced if necessary to reach a point to right or left. This forms a roller runway over which the pigs will move by gravity on a grade of from four to eight per cent., according to their character.

They claim that in most cases the cost of handling pigs can be cut in half, but occasionally adverse conditions render it difficult to get better than twenty-five or thirty per cent saving. It is stated that the investment cannot fail to be profitable in any case where carload quantities are frequently handled.

## ELECTRIC DRYING OVENS IN A ROD MILL.

Iron rods for wire drawing must be pickled in acid to remove the coat of scale before drawing. After pickling they are given a coat of lime and dried, usually in gas-fired ovens, before being drawn into wire. In Iron Age of Feb. 14th, 1918, page 441, appears an account of a recent development at the works of the National Screw and Tack Company of Cleveland, where electrically heated ovens have now been installed for this purpose. This change was occasioned by the cutting off of the previously used natural gas supply, owing to its increasing scarcity. Electrically heated ovens have been in use for several weeks, and have been found to offer various advantages as compared with the gas-fired ovens.

Each oven is heated by 24 standard low-temperature japanning electric heaters with a capacity of $3\frac{1}{2}$ k.w. each; the heaters being placed in the bottom of the oven underneath the rails on which stand the buggys loaded with the coils of wire bars. Each oven uses 144 k.w. and consumes 45 k.w. hours for each charge of bars. Automatic control of the oven temperature is obtained by a Tycox electric contact temperature control instrument, which enables the oven to be kept very constantly at the desired temperature of from 380-400 degrees Fahrenheit. The electric heating has: first, the advantage of avoiding delays in getting ready for operation at the beginning of each day. The gas fired ovens needed $2\frac{1}{2}$ hours to reach the desired temperature, but the electric ovens can be prepared for operation in fifteen to eighteen minutes. This increased speed avoids a very awkward delay every morning when rods leaving the tanks were obliged to wait and become cold before they could be treated in the oven. The speed of drying is also increased: more than $1\frac{1}{4}$ hours being needed in the gas oven, while ten or twenty minutes is sufficient in the electric oven. This may be due partly to the vapour which is present in the products of combustion of the gases and which interferes with the removal of moisture from the rods. A further advantage in the electrical oven is that the rods come out cleaner and that the dies are in consequence found to last longer. The gas heating produced a glazed coat on the rod and this coating was found to scratch the rod and clog the dies. With electrical heating the glazed coating naturally does not appear.

Electrical heating is found to cost about one-third more than gas heating in a given time, but as the output has been about doubled the net cost is decidedly less. The operation described is only one instance of the commercial uses of electrical heating for low-temperature as well as high-temperature operations. There are many cases in which electrical heating, although more costly than the heat from coal or gas, is found to compare favourably in practical operation on account of its greater cleanliness, efficiency and convenience of operation and regulation.

## ELECTRIC FURNACES IN PETROGRAD.

In view of the interest attaching to anything Russian, just now, we make no apology for printing the following letter to ourselves which seems to show that Petrograd is not wholly given over to the revolution.—(Editor.)

1/14 Dec., 1917.

W. Syrokomsky,

Assistant Chemist of the Committee

of Military Technical Help, Ing. Electro Chemist,

Zesnoi Sonorin, 2 Petrograd, Russia.

Dear Sir:

Owing to the absence of good books on electro-chemistry and electro-metallurgy in Russia, I shall be very grateful to you, if you would allow me to translate your excellent work on the electric furnace. This translation will be published by the Committee of Military Technical Help. I kindly beg your preface to the Russian edition, which we wish to publish soon.

I am, Dear Sir,

Yours sincerely,

W. Syrokomsky.

# Regulation of Air Supply for Blast Furnaces.

The air supply for blast furnaces is usually furnished by cylinder blowing engines, and these are run at varying speeds according to the requirements of the furnaces. The maintenance of the steady rate of the engine will produce a uniform supply of air by volume, but does not ensure to the furnace a constant number of pounds of oxygen per minute under varying conditions of the atmosphere. The constancy of the supply is affected, first, by the variations in barometric pressure, which cause each foot of air supplied to contain a smaller or larger weight of oxygen; second, by variations in the temperature of the air supply, which has the same effect, and third, by the humidity of the air which, replacing a certain amount of dry air by moisture, decreases the oxygen in each cubic foot. It becomes necessary, therefore, if extreme accuracy is aimed at, to correct the speed at which the engine is running in view of the indications of the barometer, thermometer and hygrometer.

An article entitled "A Volume Regulator for Blast Furnace Engines" on page 29 of the Metallurgical and Chemical Engineering for January 1, 1918, describes a regulator for the centrifugal compressor which is now being introduced for supplying air to the blast furnace. The following extracts give an idea of the method:

"With the advent of the centrifugal compressor giving a perfectly steady air blast, the metering of the air supply became more practical and, therefore, more usual. With perfectly definite and uniform charging a definite and uniform weight of air per minute is desirable. Constant-volume governors have been designed on two principles, one by metering the air by means of a venturi meter and the other by using an impact float. The venturi-meter governing has been improved by using a multiple venturi meter in which large pressure drop can be obtained in the throat without a corresponding loss in power. This difference in pressure is used on a mercury pot whose motion up and down is translated to the governing mechanism of the driver of the air compressor. The proper setting of this meter is accomplished by changing the tension of the spring until a scale calibrated in cubic feet of air per minute shows that the desired quantity of air is obtained.

In the impact float method the air is taken through a conical opening in which is suspended a float, this float moving a horizontal beam about a pivot. The horizontal beam actuates the governing mechanism of the driver of the air compressor. On this horizontal beam is a sliding weight which can be set at calibrated marks representing cubic feet of free air per minute. With the weight set in a definite position a certain definite quantity of air is obtained.

In both of these methods, however, the readings on the calibrated scale are only correct when the initial air conditions are standard, that is, are similar in barometer, temperature and humidity to which the scale has been calibrated. Any change in either the temperature of the inlet air or in the atmospheric barometer or in the humidity of the air, changes the weight of the air metered, and, therefore, its oxygen content. As the blast furnace requires an exact weight of oxygen, the above method of holding constant volume is liable, in extreme cases, to have an error of from 15 to 20 per cent.

### The Volume Corrector.

A volume corrector is herewith presented which when used in connection with the air-generating device will correct for any changes in either temperature, barometer and humidity, so that the air supplied to a blast furnace will, at all times, under any atmospheric conditions, deliver a perfectly definite and predetermined weight of oxygen to the blast furnace. This volume corrector is so designed that it requires only one setting for each correction, that is, one setting for any initial temperature, one setting for any existing barometer and one setting for humidity as usually obtained by the difference of readings on a wet- and dry-bulb thermometer."

The exact construction and use of the apparatus is given in the original article but is too long and complicated for us to reproduce. The conclusions are as follows:—

"The volume corrector therefore is an instrument which can be set by an operator at the existing barometer, temperature and humidity of the atmospheric air, and when so set will permit the setting of the sliding weight on the scale beam in a position so that the constant-volume governor will hold or deliver the correct volume of air which would contain the same weight of oxygen as would be contained in a certain predetermined and desired volume of standard air.

This means that the blast-furnace operator, knowing the chemical compositions of the coke and iron ore and the amounts charged to the furnace in a stated period of time, can determine the exact volume of standard air (dry, 60 deg. fahr., 29 in. Hg) which will contain the proper amount of oxygen necessary for combustion of the coke and reduction of the iron ore on the blast furnace. He need not perform any mathematical calculations as to how much more or how much less air must be supplied when the atmospheric conditions are not those considered standard in order to be sure the blast furnace is receiving at all times its exact and necessary weight of oxygen.

The volume corrector needs resetting every time the operator notices any change in the barometer, temperature or difference between the wet- and dry-bulb thermometer reading in order to be sure of securing the most efficient regulation. The air conditions, however, do not vary rapidly and the practice of inserting in an engine-room log every half hour the steam pressure, r.p.m., vacuum and other information can easily be extended to include readings of the barometer, thermometer and wet- and dry-bulb instrument. Even with the front cover of the volume corrector closed, transparent places are provided which will permit any one checking or observing these settings. The need of a volume corrector is apparent from the fact that it is possible to have a variation of weight of oxygen delivered to a furnace of 5 to 10 per cent ordinarily and in extreme cases as high as 20 per cent as a result of variations in atmospheric-air conditions, especially as between winter and summer. The gains in quality and quantity of output of a blast furnace obtained even by the former methods of constant-volume governing without volume corrections will be still further improved by the use of constant-volume governing with proper volume corrections."

ELECTRIC STEEL AND METALS CO., WELLAND.

# IRON & STEEL
## OF CANADA

A Monthly Magazine devoted to the Science and Practice of the Iron, Steel, Foundry, Machine and Metal-working Industries, with an up-to-date review of conditions in these and allied industries and trades

ALFRED STANSFIELD, D.Sc., Editor-in-Chief.
W. G. DAUNCEY, M.E., Associate Editor.

The editors cordially invite readers to submit articles of practical interest, which, on publication, will be paid for.

Subscriptions to any address in Canada, the United States and the British Empire, $2.00 yearly. Other countries Postage Extra. Single copies, 25 cents.

Published on the first of each month by
THE INDUSTRIAL AND EDUCATIONAL PRESS, LIMITED.
J. J. Harpell, President and Managing Director.

A. S. Christie, Eastern Manager.
H. W. Thompson, Western Manager.

Montreal Office:
35-45 St. Alexander St.
Telephone, Main 2662.

Toronto Office—
C. P. R. Building, cor. King and Yonge Sts.
Telephone, Adelaide 3310.

Changes for advertisements should be in the Publishers' hands ten days before date of issue.

Vol. I. MONTREAL, APRIL, 1918 No. 3



FRONTISPIECE—Electric Steel Furnace at Welland.

EDITORIAL—

| | |
|---|---|
| Iron and Steel section of Canadian Mining Institute | 105 |
| The War Crisis | 105 |
| Canadian Society of Civil Engineers | 106 |
| Canadian Mining Institute | 108 |
| Concrete Ships | 108 |
| Copper Nickel Steel | 109 |
| Montreal Metallurgical Association | 109 |
| Defects in Steel Ingots and Forgings, by S. W. Werner and Gordon Spencer | 110 |
| American Clay for Graphite Crucibles | 116 |
| Steel Wheels are becoming popular | 116 |
| Steel Treating Research | 117 |
| Thomas Cantley, by J. C. Ross | 118 |
| PORTRAIT of Thomas Cantley | 120 |
| PORTRAIT of Robert Hobson | 121 |
| Robert Hobson, by J. C. Ross | 124 |
| Fahy-Permeameter for Magnetic-mechanical analyses of Iron and Steel | 124 |
| Hamilton and the Iron and Steel Industry | 126 |
| Electric Steel Melting Furnaces | 128 |
| A New Electric Furnace | 128 |
| Electric Steel Making at Welland | 130 |
| Electric Melting of Steel | 130 |
| Foundry of Electric Steel and Metals Company, Welland | 131 |
| Fuel and Power Problem of Canada | 132 |
| Grants for Industrial Research | 133 |
| Effect of Copper on Medium Carbon Steel, by C. R. Hayward and A. B. Johnston | 134 |
| Nickel-Copper Steel, by R. W. Leonard | 135 |
| Cobaltcrom—Errata | 139 |
| Slag Difficulties in Continuous Billet-heating Furnace, by H. S. Grove | 140 |
| A Problem in Large Heating Furnaces | 140 |
| Defects in Ingots and Forgings | 141 |
| Hamilton Notes | 141 |
| Walter Baker Champ | 142 |
| Cold Rolled and Cold Drawn Steel | 142 |
| "Concretia" launched in Montreal | 143 |
| Manitoba Steel Foundries | 144 |
| Pure Sheet Nickel | 144 |
| Grain—Size Measurements, by Zay Jeffries | 146 |
| Notes from Nova Scotia | 146 |

# EDITORIAL

## IRON AND STEEL SECTION OF CANADIAN MINING INSTITUTE.

A few months ago a movement was inaugurated in the Canadian Mining Institute for the formation of an Iron and Steel Section of the Institute on lines similar to the Iron and Steel Section of the American Institute of Mining Engineers. The object of this movement was not to divide the present membership of the Institute into two groups—the iron and steel and the non ferrous—but rather to build up a new department of the Institute, which would be recruited largely from those who were not at that time members of the Institute.

It was recognized therefore that the first thing to do was to put the matter before the leading men in the Iron and steel Industry, and to learn from them whether such an organization was desirable from their point of view, what useful purposes could be served by it, and what kind of an organization would be most suited to their requirements. The Management and Editorial Board of the "Iron and Steel of Canada" have devoted much time and attention to this matter, and have been fortunate in securing the active interest of a number of the leading men in the Industry.

Throughout the deliberations our own aim has been to give full opportunity for the free discussions of these questions, and to guard as far as possible against limiting the nature of the discussion or the conclusions arrived at by any preconceived opinions of our own or others. The organization of the Iron and Steel Industry of Canada was largely a new idea to most of those who attended the organizing meetings, and we realized that ample time must be allowed for full interchange of thought and formation of opinions before any final action could be taken.

Many workers in the Iron and Steel Industries have in the past taken no interest in the Canadian Mining Institute, and have felt in consequence that their natural affiliation would be rather with some general Engineering Institute like the new Engineering Institute of Canada. At one stage in the deliberations it was considered that the Iron and Steel men should organize themselves independently and then consider the question of affiliation with the Canadian Mining Institute.

At the annual meeting of the Canadian Mining Institute a session was set apart for the consideration of the subject and the practice in the American Institute was explained by Mr. Bradley Stoughton. The Iron and Steel representatives present decided to organize the industry as a part of the Institute, provided such an organization were found to be practicable; a resolution to this effect being proposed by Mr. D. H. McDougall, and seconded by Mr. F. Crockard. A committee of prominent Iron and Steel men was nominated for the purpose of studying the matter further, and conferring with the Council of the Institute with a view to the initiation of the Section.

The Iron and Steel Industry forms a large and important part of Canadian production, and it is unquestionable that the organization of this industry should be undertaken. It is also undeniable that the greatest care should be taken to avoid duplication of effort and division of interests, such as has taken place in the United States, where the iron and steel industry is represented by two separate organizations, an Iron and Steel Institute, and an Iron and Steel Section of the American Institute of Mining Engineers.

Care will have to be taken to allow the new Section sufficient liberty of action, so that it can fulfill the functions served by both the American organizations and can achieve the esprit de corps, which is essential to satisfactory growth, and yet to obtain this with an organization that will lead to unity of the whole Canadian Mining Institute. The problem presents certain difficulties, but we believe that a satisfactory solution can be found.

## THE WAR CRISIS.

As a technical paper we do not as a rule refer directly to the progress of the war, although it is at the back of all our endeavors and unconsciously colors our whole life. When, however, during those anxious days about Easter, it seemed possible that the British and French line might be broken and the bulwarks of civilization swept away, all true Canadians must have realized afresh our dependence on the devoted men who are holding the foe in France. If they were to fail of how little value would be anything we could do here? People live carelessly on the slopes of a volcano, and it may need a crisis like the present to remind us that the war is not yet over, and that every effort must still be made by supporting those at the front with men, money and supplies to preserve all that is worth having for ourselves and our children.

## CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Society has recently inaugurated a change of programme leading to a considerable enlargement of its operations. One evidence of this was the "First General Professional Meeting" of the Society, which was held in Toronto on the 26th and 27th of March. This meeting was arranged by the Ontario Branch of the Society, and was very well attended by delegates from all parts of Eastern, and some even from Western Canada. The papers presented dealt in one way or another with the subject, so pressing at the present time, the supply of fuel and power for Canadian consumers. This subject is not only of painful personal interest to those who have to live in the northern latitudes, but it is of the first importance to workers in the iron and steel industries, fuel itself being an essential ingredient of iron and steel making, and working, and even where the fuels referred to are not actually used in the iron and steel industries, their use for domestic purposes releases some other fuel which can be used industrially.

On the morning of Tuesday, the 26th of March, 1918, the members visited the plant of the Canadian Aeroplanes, Ltd., and the plant of the British Forgings, Limited, at Ashbridges Bay.

The latter plant was seen in full operation under the guidance of Mr. Durfee and other members of the staff.

The visitors saw the scrap material waiting to be turned into shells.

The large furnace house contains ten Heroult Electric Furnaces. They are rated at six tons capacity, but produce somewhat more than that. About seven of these were in operation at the time, and the daily output of about 250 tons of shell steel ingots. If ten furnaces were in operation tonnage would be increased accordingly.

The visitors saw the casting of eight tons of molten steel into 70 odd billets for shell making.

The cast billets are carried on the mechanical conveyor to the Cutting Off Shop, where the top of each is taken off the ingot, and the fracture submitted for inspection.

From there it is taken to the Forge Shop, heated in oil-fired furnaces and forged into shell shape.

The machining of the shell is not done in this plant.

In the afternoon the delegates listened to an opening address by Sir William Hearst, Prime Minister of Ontario, in which he pointed out the importance of the topics to be discussed at the meeting, and expressed his belief that the Government would value and utilize the results of the deliberations. The following papers were read during the remainder of Tuesday and Wednesday:

THE FUELS OF CANADA—Mr. B. F. Haanel, Chief of Fuel Division, Department of Mines, Ottawa.

Discussion—Mr. L. M. Arkley, M. Can. Soc. C.E., Assistant Professor of Mechanical Engineering, Toronto University.

TRANSPORTATION FROM THE FUEL VIEWPOINT—Mr. W. N. Neal, General Secretary of The Canadian Railway Association for National Defence, Montreal, Que.

THE RATIONAL DEVELOPMENT OF CANADA'S COAL RESOURCES—Mr. W. J. Dick, A.M. Can. Soc. C.E., Mining Engineer of the Commission of Conservation, Ottawa, Ont.

UTILIZATION OF PEAT—Mr. John Blizard, A.M. Can. Soc. C. E., Technical Engineer Division of Fuels and Fuel Testing, Mines Branch, Department of Mines, Ottawa, Ont.

Discussion—Mr. James Milne, M. Can. Soc. C.E., Mechanical and Electrical Engineer, Department of Works, City of Toronto.

THE LOW TEMPERATURE CARBONIZATION AND BRIQUETTING OF BITUMINOUS COALS — Mr. E. Stanfield, Division of Fuels and Fuel Testing Mines Branch, Department of Mines, Ottawa, Ont.

AN ILLUSTRATED ADDRESS ON "THE ERECTION OF THE QUEBEC BRIDGE"—Mr. Geo. F. Porter, M. Can. Soc. C.E., Engineer of Construction, St. Lawrence Bridge Company, Montreal, Que.

ONTARIO'S EFFORTS TO RELIEVE THE FUEL SITUATION—Mr. Albert Grigg, Deputy Minister, Department of Lands and Forests, Ontario, Toronto, Ont.

WOOD AS AN EMERGENCY FUEL—Mr. E. J. Zavitz, Provincial Forester, Ontario.

GAS FOR LIGHT, HEAT AND POWER—Mr. Arthur Hewitt, General Manager, Consumers' Gas Company, Toronto.

CENTRAL HEATING AS A MEANS OF CONSERVING FUEL — Mr. F. G. Clark, M. Can. Soc. C.E., Chief Engineer, Toronto Electric Light Company, Toronto, Ontario.

OIL FUEL AND THE POSSIBILITIES OF ITS USE—Mr. R. W. Caldwell, Chief Mechanical Engineer, Imperial Oil, Limited, Sarnia, Ont.

CANADA'S WATER POWERS AND THEIR RELATION TO THE FUEL SITUATION— Mr. J. B. Challies, M. Can. Soc. C.E., Superintendent of Dominion Water Power Branch, Department of the Interior, Ottawa, Ont.

Discussion—Mr. H. G. Acres, M. Can. Soc. C.E., Hydraulic Engineer, Hydro Electric Power Commission of Ontario, Toronto, Ont.

RAILWAY ELECTRIFICATION—Mr. John Murphy, M. Can. Soc. C.E., Chief Electrical Engineer, Department of Railways and Canals, Ottawa, Ontario.

THE POSSIBILITIES OF THE RELIEF OF FUEL CONSUMPTION IN CANADIAN INDUSTRY BY THE INCREASED USE OF HYDRO-ELECTRIC ENERGY—Mr. J. M. Robertson, M. Can. Soc. C.E., Director, Southern Canada Power Co., Montreal, Que.

THE POSSIBILITIES OF LESSENING FUEL CONSUMPTION IN CANADA BY THE ADOPTION OF ELECTRICAL HEATING — Mr. P. H. Mitchell, A.M., Can. Soc. C.E., Consulting Engineer, Toronto, Ontario.

---

The subjects discussed related in the first place to the problem in ordinary times of obtaining and distributing fuel and electric power throughout Canada. The principal fuel, coal, being found only in the eastern and western parts of the Dominion the transportation problem is a serious one, and the central portion, which is termed "the acute fuel area" is so remote

from Canadian mines, that it has been largely served by imports from the United States. The natural difficulties of the situation have been increased by the war, which has had the effect of diminishing the supplies, as a number of the miners have gone to the front, and has also interfered seriously with the transportation of coal to distant points. Thus the coal mined in Nova Scotia was taken to Montreal and other points partly by steamer and partly by railway, but the steamers have been taken off for war purposes, and the railways are unable to handle the whole of the traffic. In addition to this, the decreased production of coal in the United States and the congestion in their transportation system has made it extremely difficult to supply the central areas of Canada with anthracite and bituminous coal as in the pre-war times. It may be added that the officials in the United States have been extremely generous in their treatment of Canada in these trying times, and have sometimes even given Canadian consumers a preference in directing the supplies. We recognize their generosity in this matter, but must realize that as they have curtailed their own consumption of fuel, we are obliged to do everything we can by reducing our requirements as well as by economy in our use of fuel to lessen our claims on their supply, and throughout Canada it is essential that every available source of fuel shall be developed as far as possible with a view to replacing the imports of coal on which we depend to so large an extent at the present time. It may be added that there is a certain reciprocity in the fuel situation, as some of the Nova Scotia coal is shipped to points south of the line, and also as we export considerable quantities of electric power from Niagara Falls.

It has been supposed by soem that the fuel difficulty is purely temporary, and that it is not likely to recur during the following winter. There is, however, no sufficient reason for supposing that this will be the case, and it is absolutely essential that everything possible shall be done to render ourselves independent of outside supplies of fuel for the following winter, and to some extent permanently.

The means proposed for remedying the situation were of two kinds, temporary and permanent. The temporary shortage of fuel can be met most effectively by the provision of wood for burning in domestic furnaces. Powers have been given by the Fuel Controllers for the municipalities to cut wood for their own needs on the Crown Lands. This provision would be excellent, but it has been rendered of less value because the cutting operations have not yet been started to any considerable extent, owing mainly to the impossibility of obtaining labor, and wood, to be of any value as fuel, should be cut several months before it is to be used, so that it may have an opportunity of drying. In the central provinces some assistance can be obtained from the burning of lignite. This fuel has the disadvantage that when kept it dries and crumbles to powder, which is then unsuitable for burning in ordinary furnaces. In consequence of this property, it has been the custom to mine and ship the lignite only during the fall and winter months, with the result that it was very difficult to obtain transportation facilities, especially as the grain harvested in the fall had to be shipped at the same time and in the same direction. This circumstance has in fact led to a large importation of American coal, which can be moved westwards along our railways, although there was available the unused coal in British Columbia. It is now recommended that lignite be mined and shipped during the spring and summer, and that consumers bury it in pits in the ground, where it can be protected from the air and kept in moist lumps. It was pointed out, however, that this precaution does not entirely overcome the difficulty, as lignite even when kept in lumps is liable to crumble away in the fire as it dries. A permanent solution of this difficulty is expected in the near future by a low temperature carbonization and briquetting process, which enables lignite coals to be changed into permanent fuels, similar in kind but better than the anthracite now in use for heating.

Another device for meeting the fuel shortage will be the use of bituminous coal, which can be obtained more freely than anthracite, both in Canada and the United States. Further devices for temporary use will consist in the use of gas and electrical heating whenever possible as substitutes for anthracite for heating and cooking. At the present time gas is not sold cheaply enough for general heating purposes. It appears probable that by remodelling the gas plants, fuel gas can be produced and distributed to houses at a price which should permit of its use for heating, as well as cooking, but the gas companies at the present time have so much difficulty in meeting existing demands on their product that they are not anxious to encourage any further development in this direction. It is pointed out that in some places electrical power can be used as an auxiliary source of heating, rendering it unnecessary to light the furnaces at certain times of the year. This device may be useful as an expedient, and it utilizes water-power which is constantly replenished, instead of coal, which, when once burnt, can never be obtained again, but it must not be supposed that electrical heating can be used to any considerable extent for heating houses. This is caused partly by the necessarily high cost of electrical heat, and also by the limited supply of this source of heat as compared with the supply of coal.

No matter what may be done for the production and distribution of additional fuel, there is no doubt that we must economize so far as possible in its use. We must, for example, accustom ourselves to keeping our houses cooler and wearing thicker clothes during the coming winter, with the object of saving fuel.

Under the head "permanent measures for developing the supply of fuel in Canada" may be mentioned the peat industry. Many attempts have been made and much money has been wasted in experimenting on the production of peat fuel, but the results have not been entirely negative, and there is a prospect at the present time of the peat industry being at last put into a satisfactory condition. It seems doubtful whether we shall be able to receive much assistance from peat during the coming winter, but before long peat fuel and electric power supplied from that source will be available in parts of Ontario which are not easily served by eastern or western Canadian coals. The use of wood may also be developed to a large extent. It was pointed out that the trees most used for commercial purposes were the soft pulpwood trees, and that the effect of cutting these trees was to change the forests from soft wood to hard wood, as the hard wood trees spring up and fill the places vacated by the soft wood trees. It was recommended that systematic cutting of the hard wood as well as the soft wood trees be carried out, using the

hard wood as fuel, and thus maintaining a growth of soft wood trees for industrial use. The wood annually wasted throughout the forests of the Dominion would be amply sufficient to heat Canadian homes. The production of briquets from lignite has already been referred to. This must be developed into a permanent industry for domestic and industrial purposes. The mining of coals in western Canada must also be more regularly developed. At present the operations of the mines are irregular, and therefore costly. Much of the fuel, moreover, remains as a powder at the mine and is wasted. All these points must be looked into and remedied, if we are to have a satisfactory and economic supply of fuel. Electrical energy, whenever available, should be developed and used in place of coal for the production of power.

In regard to the heating of cities, central heating plants, using steam for heating a few or many buildings, were considered. It was shown that considerable economy could be effected even on a small scale, as for example, the heating of a block of perhaps thirty buildings from a central steam plant. In the more distant future gas heating will probably go into effect, and it was even predicted that coal from the mines could be powdered and propelled through tubes to the points where it is to be used. One speaker, referring to the improvements that were possible by the efficient use of fuel, stated that a householder, instead of buying one ton of anthracite coal for $11.00, would in the future be able to obtain for less money one ton of an artificial anthracite, free from slate, 40 miles of motor fuel, fertilizer for starting a small garden, tar to lay the dust in front of his residence and one month's supply of gas.

## THE CANADIAN MINING INSTITUTE.

A successful annual meeting of the Institute was held in Montreal on the 6th, 7th, and 8th of March, when a number of important papers were read and discussed and the members utilized to the full the opportunity for reunions for which these meetings are famous.

Amongst the papers read we may mention as of interest to iron and steel workers the following papers which we hope to discuss later. First, two papers by Col. David Carnegie and Mr. C. V. Corless which dealt with the organization of industry, capital, labor and trade in order to produce more satisfactory industrial and social conditions. Next, papers on the fuel situation by Messrs. B. F. Haanel, W. J. Dick, E. T. Conner, J. G. Davidson, D. B. Dowling and others. Also the following papers of direct interest to the iron and steel industry: The manufacture of nickel-copper alloy steel (Nicu Steel), by Mr. G. M. Colvocoresses, mentioned elsewhere in this issue; Canadian Ship Building, by Col. Thos. Cantley; The manufacture of Ferro Alloys in Canada, by Mr. G. C. Mackenzie, and The manufacture of Crucible Pots for Steel Melting, by Mr. C. F. Bristol.

A View taken during the Annual Meeting of the Canadian Mining Institute, at Montreal.

The most important feature of the meeting was probably a special session at which the formation of an Iron and Steel Section of the Institute was decided upon, particulars of which will be found elsewhere in this issue.

Owing to a surplus of interesting and instructive matter for this issue, we have reluctantly been compelled to hold over several papers and editorials, the former include The Use of Producer Gas in Metallurgical Industries, by Mr. Percy Cole; Foundry Moulding Sands by Mr. L. Heber Cole, and The Blast Furnace, by Mr. W. G. Dauncey.

## CONCRETE SHIPS.

On page 143 we publish an illustration showing the first concrete ship built and launched on the American continent. The keel was laid on September 7th, 1917, and the boat was launched on November 14th, 1917. The overall length is 126 feet 6 inches, the width 22 feet 6 inches, and the depth 12 feet 6 inches, and accommodation in provided for a crew of seventeen. The mechanical equipment, provided by the Hall Engineering Company and Montreal Dry Dock, includes compound engines, with 12 inch and 24 inch cylinders, and an 18 inch stroke, Fitzgibbon boiler and steam steering gear. It is the property of the Montreal Shipbuilding Co., Limited, and was built by the Atlas Construction Company.

## COPPER NICKEL STEEL.

Until a few years ago it was commonly supposed that copper had a harmful effect on iron or steel, making it red short, and a limit to the copper contents of steel was sometimes set in specifications. We realize now that this was one of the superstitions of the industry, many of which doubtless still linger unrecognized for what they are. Red shortness may have been caused by sulphur, a common associate of copper, but it seems probable that the copper, which was found in some steels, was used as a scapegoat on which to place bad properties which the steel makers could not account for.

We reproduced in this issue a paper by C. R. Hayward and A. B. Johnston on the effect of copper in medium carbon steel. Two lots of steel were obtained containing about 0.37% of carbon and 0.58% of manganese. One lot of steel contained 0.86% of copper and the other only 0.03%. These steels were prepared, heat-treated and tested with every precaution necessary to ensure comparable results. The "high copper" steel was found to have a decidedly higher yield point and ultimate strength than the "low copper" steel and the elongation and reduction of area were about the same. The high copper steel was harder than the low copper steel and was superior under the Charpy stock test.

The effect of copper on steel is closely related with an attempt which is now being made to utilize more efficiently the enormous deposits of nickel ores occurring in the Sudbury district. These ores contain on an average about 3.25% of nickel, 1.7% of copper, 40% of iron, 25% of sulphur and 30% of silica and other rock matters. During the present year some 1,600,000 tons of ore will probably be mined and treated in the Sudbury district. To recover the 5% of nickel and copper, the ores are roasted in heaps, smelted and bessemerized with the effect of driving off into the air some 400,000 tons of sulphur, having a gross value of 16 million dollars, and pouring over a dump in the form of slag about 640,000 tons of iron, equal to half the production of pig iron in Canada. The utilization of the sulphur, and the prevention of the annoyance it causes, have often been considered. The sulphur could be converted into sulphuric acid, but it appears that the difficulty of transporting the acid to market would be a fatal objection. Steps must be taken before long, however, to find a satisfactory solution of this problem.

The situation with respect to the iron is different and offers a more immediate remedy. At present smelting and bessemerizing processes are employed largely for the purpose of separating from the 5% of nickel and copper, the 40% of associated iron. The nickel, copper matte so produced must then be submitted to elaborate refining processes, either in England or the United States, for separating from each other and purifying for market the metals nickel and copper. When this has been done, some three-quarters of the resulting nickel is immediately mixed with steel obtained from other sources for the production of nickel steel. As the nickel is wanted as an alloy with iron why go to the expense of separating it in the first place, and why throw away the iron with which it was associated in nature? The following reasons, among others have probably operated to produced the present condition:

1. The ore was originally mined and smelted for copper, and copper smelting methods, which always involve the waste of all the iron in the ore, were naturally adopted.
2. The iron is associated with sulphur in the ore and in the past it was not considered practical to employ such ores for the production of iron.
3. The iron and nickel are associated with copper, and it was supposed that copper would be fatal to steel.

At the present time we can ignore reasons 1 except insofar as vested interests are concerned; reason 2 is no longer valid, because improved roasting methods enable pyrites to be used as an ore of iron, after the sulphur has been recovered as sulphuric acid. We have seen that copper increases the strength of steel without decreasing its ductility and it has been proved, independently, that the nickel in a nickel steel can be replaced to the extent of about one-fourth with copper, without detracting from its mechanical properties. On this account reason 3 falls to the ground and we are confronted with the possibility of producing a steel containing the iron, nickel and copper of the Sudbury ores and which shall be of the same quality as nickel steel made by the usual round about and wasteful process.

Broadly speaking it has been found that the Sudbury ores can be treated by iron-smelting methods for the production of a nickel copper steel, providing the copper, in the ore selected for this process, is not more than about one-third of the nickel.

The progress that has already been made in this direction, and the developments that are expected in the future are described in a paper by Col. Leonard, which we print in this issue, and in a paper by Mr. G. M. Colvocoresses, the inventor of the process, which we hope to print later.

The new process can be applied: (a) to ores in which the copper is not more than one-third of the nickel; and (b) to not more than three-fourths of the ores treated, as pure nickel will still be needed for plating and the production of non-ferrous alloys. It must be added that although the tests so far made have been favorable to the new steel, we cannot feel entire confidence until it has been tried out on a large scale for the manufacture of guns, armour plate, and the other products for which nickel steel has been used.

---

## MONTREAL METALLURGICAL ASSOCIATION.

We reproduce in this number a paper by Messrs. S. W. Werner and A. Gordon Spencer, on "Defects in Steel Ingots," which was read at the February meeting.

The annual meeting of the association will be held on April 10th, when business will be transacted including the election of Members of Council for the ensuing year. A paper on the properties of nickel-copper steels and a new way of smelting nieckl ores of Sudbury will be read and discussed.

# Defects in Steel Ingots and Forgings

By S. W. WERNER and GORDON SPENCER.

It is a matter of some difficulty to produce steel of the highest quality at all times, and is daily becoming more difficult owing to the scarcity and high price of pig iron and good scrap coupled with the necessity of using a lower grade of these raw materials than would usually be permitted. The great demand for steel for all classes of munitions has made it imperative that none should be wasted, but that all should be utilized which can be refined to the proper degree of purity. The steel manufacturer at the present time is required to produce sound ingots often from raw materials of a lower grade than previously, and is in addition under great handicaps from scarcity of labor and fuel. A study of the more common defects found in ingots and forged steel, and their causes may therefore be of some interest at the present time, particularly as regards the defects found in steel used in making shell forgings.

The production of a sound ingot is not as easy as it may seem at first sight and is greatly affected by the conditions of manufacture and subsequent rolling, forging or heat treatment. Sometimes they are cumulative in their total effect, sometimes the primary defects may be removed or reduced by the later operations. In any case the greatest care is necessary at all stages in order that sound material of the requisite physical qualities may be finally obtained.

The steel as cast from the ladle into a mould may on solidification show to a more or less degree the following defects:—

(1) Blowholes, or gas pockets in the body of the metal, and pin holes (surface blow holes.)
(2) Pipes, or shrinkage cavities.
(3) Ingotism, or the formation of large sized crystals.
(4) Segregation, or the local concentration of impurities.
(5) Checking or cracking (sometimes internally), produced by strains set up in the cooling of the metal.
(6) Seams.

While the elimination from bad steel of these defects will not make it good, their presence will very often make good steel bad. Fortunately the remedy for one defect will often reduce or remove another. For example, steel which is sound and free from blowholes or intermingled slag is less liable to segregation and piping.

### Blowholes.

Molten steel readily dissolves certain gases, such as hydrogen, nitrogen and oxygen, which are thrown out of solution during solidification. Unless sufficient time is given for their escape they may become trapped and will then form gas bubbles or blowholes, the size of the latter depending on the quantity of gases entrapped. The formation of blowholes may be almost entirely prevented by allowing sufficient time for the gases to rise through the still molten part of the ingot and escape. The addition of certain reagents, such as aluminum, is said to hold them in solution and to prevent their separation in the form of free gas bubbles. The most common cause of blowholes is undoubtedly oxygen. This may be derived from old rusted scrap or small steel turnings used in the original charging of the steel furnace, and which had not become completely reduced in the refining operation. It may also be derived from the later oxidation of the molten metal while in the furnace or as it was poured from the furnace into the ladle or from the latter into the moulds. Various deoxidizing agents are added to reduce the oxide of iron so formed and to remove the oxygen. The principal deoxidizers are manganese, silicon, aluminum and titanium. They seem to act partly by deoxidizing the iron and partly by increasing the solvent power of the solid metal for gases so that a less amount separates.

Blowholes may be near the surface

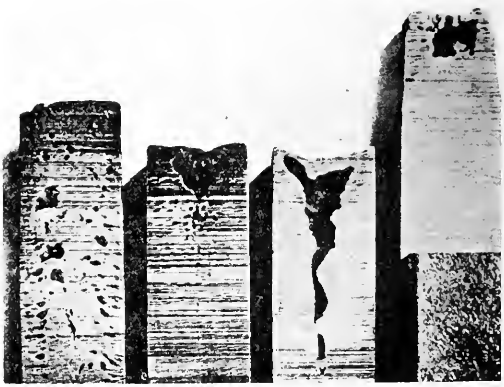


Fig. 1.—Sections of steel ingots showing blowholes and pipes.

or near the centre of the ingot, or both. See Fig. 1. Those near the outside, on reheating, tend to break out in the form of pin holes, which on account of the oxidizing of their surfaces will not weld up again. Where several occur close together a crack is very often found which extends from one to the other, and may be as deep or deeper than the original holes. When such ingots are reheated previous to rolling or forging these pin holes or cracks will not weld, but often become filled with more oxide, sometimes with slag from the furnace lining and very often increase in size. When rolled into blooms and bars they appear as seams or fissures. When the cast ingot is forged directly into a shell they may become seams or still show as pin holes (near the base of the shell.)

Where the blowholes are completely surrounded by metal they become elongated in rolling, but remain as cavities more or less thread-like in shape

*Presented before the Montreal Metallurgical Association, February 13th, 1918.

and often broken up into short sections, parallel to the direction of rolling. (Fig. 2.)

**Pipes.**

When steel is "teemed," or poured out of the ladle that portion next the cold surface of the mould solidifies first, so that a shell of solid steel is formed enclosing a body of still molten metal. This shell conducts the heat away from the centre into the walls and bottom of the mould and increases in thickness as the solidification proceeds towards the axis. The upper part usually remains molten longer than the rest, especially when protected by a top covering of non-conducting material. In cooling, the steel also undergoes contraction in size so that a cavity or pipe is formed in the central portion of the ingot. This pipe may extend down along the axis of the ingot even as far as the bottom—its depth depending on various factors; such as, original temperature of the steel, rate of

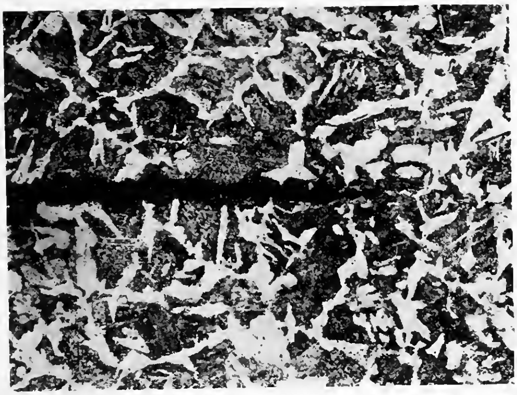


Fig. 2.—Section of steel bar showing part of an elongated blowhole. X90.

pouring and cooling, composition and percentage of impurities and so forth. (Fig. 1, No. 3.)

Pipes formed in this manner are termed "primary," and are usually near the top. In some cases, due to uneven rate of cooling, the upper part may cool too quickly and solidify while still liquid underneath. As the lower part becomes solid it continues to contract and a "secondary" pipe is then developed completely surrounded by solid metal. This is most likely to occur in small ingots where the total body of metal is relatively small as compared with the mass of the mould containing it. Primary pipes are exposed to the air and their surfaces are covered with a coating of oxidized metal. Secondary pipes may contain gases evolved from the solidifying steel and may also be more or less oxidized, but in some cases their surfaces are quite bright and free from oxide and on further rolling or working will weld together again.

Since any steel containing a pipe is unsuitable for further use and has to be cropped from the sound portion of the ingot, various means are taken to prevent piping, or at least, to keep the pipe as small and as near the top of the ingot as possible. By pouring the steel at a fairly low temperature and as slowly as possible the metal will solidify from the bottom upwards and any pipe which may form is immediately filled u pwith fresh metal. The top of the mould is sometimes lined with some non-conductor of heat such as fire clay so as to keep the top of the ingot at hot as possible. (Fig. 3.)

and in certain cases the top of the mould itself may be heated just before use for the same purpose. Immediately on completion of the pouring of the ingot a cover is put on so as to retain the heat as long as possible. A covering of slag or slag wool is also recommended and is said to give excellent results. Some firms subject the ingots to compression while the centre

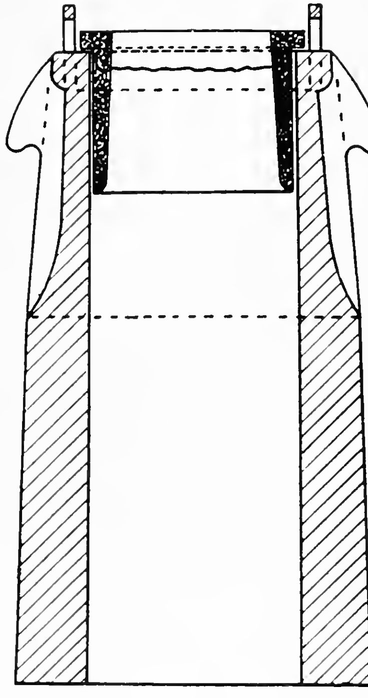
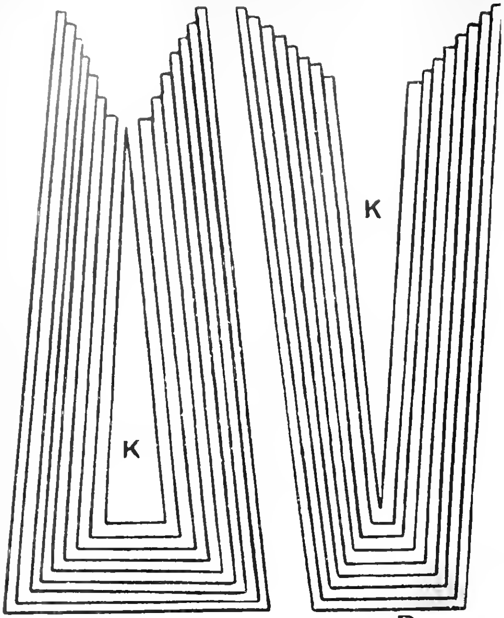


Fig. 3.—Gathmann Ingot Mould with Clay Sink-Head.

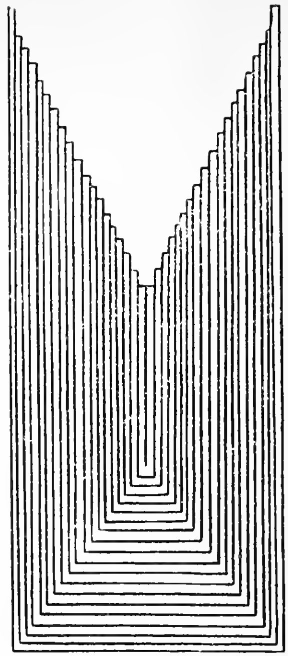
is still liquid and aim to prevent piping in this way. Among other remedies are: (a) keeping the metal liquid by an electric arc, (b) by casting in a vacuum, (c) by the addition of thermit or of some similar mixture which will create a high temperature on the top.

The design of the mould has the greatest effect on the size and position of pipes. The mode of solidification of steel in a mould which is smaller at the top than at the bottom is shown in Fig. 4—A. The parallel lines connected at the corners show the thickness of the solid shell of steel as the cooling of the ingot proceeds. It will be seen that such an ingot will tend to become solid at the top while the central portion is still liquid and that on further cooling a secondary pipe will be formed.




A B

Fig. 4.—Diagram to show Freezing of Ingot in Taper Moulds.



C

Fig. 5.—Mould with parallel sides.

Fig. 5 shows a mould with parallel sides and the straight lines connected at the corners indicate the progress of solidification. By careful pouring and by keeping the top of the mould hot a sound ingot may be obtained, particularly if the mould be so designed that the walls are thicker at the bottom so that it absorbs the heat more quickly from the lower part of the ingot. This is very difficult, however, especially when it is required to cast a long ingot of relatively small cross-section. In any case the pipe is likely to extend down along the axis to a greater depth than if a tapered mould were used as shown in (Fig. 4—B.)

In a mould of this type where the bottom of the ingot has a smaller cross-section than the top the solidification proceeds from the bottom upwards, so that the pipe is usually very near the top and does not extend very far down in the centre. Less metal must, therefore, be cropped from such an ingot in order to remove such a pipe than is necessary in the cases where moulds of the two previous types are used. On the other hand, from the point of view of the forging manufacturer a tapered ingot is more difficult to forge, so that a straight sided mould is to be preferred wherever the ratio of length of ingot to area of cross-section will permit. For example, large ingots for rolling into bars and rails are usually tapered, also smaller ingots at the present time for forging into 6" shells. For 1.5" shells which are short and of relatively great width a solid ingot may be obtained in a straight sided mould.

Moulds with corrugated or ribbed walls are also [illegible] to obtain the same effect of quick cooling from the bottom of the ingot. In some cases the ribs extend to the full height of the mould, in other cases only part of the way and often with a tapered side as well.

The degree of piping and its shape are also largely influenced by the method and rate of pouring the steel into the mould from the ladle. Top pouring is said to given a longer pipe than where the metal is introduced through the bottom of the mould. When the ingot is poured too quickly from the top the metal at the bottom is kept heated by the fresh additions of molten steel, so that it does not have sufficient time to solidify before the entire mould is full. Solidification then proceeds throughout the whole mass at practically the same rate and as a result a long central pipe is likely to be obtained.

### Ingotism.

Steel in the liquid state acts in the same manner as a hot concentrated solution of brine, which as it cools down begins to deposit crystals of salt. When a vessel containing a very strong hot brine is immersed in another vessel of cold water or ice, crystals of salt begin to form around the cold sides and gradually grow towards the centre as the temperature is lowered by conduction of the heat through the solid crystals into the colder water of the outer vessel. Crystals of pure materials, when free to grow, always form definite shapes and grow equally along their axis in each direction. When two or more crystals are growing in the same solution they will continue to increase in size in a regular manner until they come in contact

with adjoining crystals and, being stopped in one direction, they grow around and between any obstructions and so tend to form more or less irregular shaped crystals. Any impurities present in the solution are not absorbed by the crystals, but become gradually concentrated in the mother liquor until such time as they begin to form crystals themselves and seperate out in between the crystals of salt or in the centre of the now nearly solid mass. The size of the brine crystals will depend on the rate of cooling; the more slowly the heat is conducted away the larger will be the crystals. They will also be more or less elongated in the direction of the flow of heat.

In a similar manner liquid steel in cooling in a mould first forms crystals next to the cold wall or bottom of the mould, and continue to grow inwards towards the centre, branching out more or less like the branches or dendrites of a tree, until they completely fill the

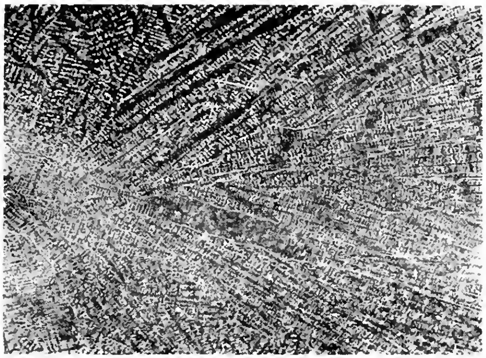


Fig. 6.—Section of Steel Ingot Showing Dendritic Growth of Crystals.

mould. Any impurities as before mentioned, are rejected and may either be caught in between the crystal branches or may eventually become concentrated in the central portion of the ingot. Their size will depend upon the rate of cooling and their general direction of growth upon the shape of the mould.

Under certain conditions of initial pouring temperature and rate of cooling an ingot of steel will therefore be more or less coarsely crystalline in structure. The surfaces of the crystals will all be planes of weakness, and on breaking such an ingot the fracture will proceed along these inter-crystalline boundaries and the peculiar coarse structure called "ingotism" will be obtained.

Cast steel as thus obtained is more or less weak and unfit for severe use. By heating it up above the critical range and for a sufficient length of time the coarse crystals are destroyed and on cooling a more uniform, fine-grained structure obtained. The impurities still remain more or less segregated along the original crystal boundaries, and the axis of the ingot, and may constitute points or lines of weakness where cracks or rupture may develop under strain. By rolling or forging these are broken up and elongated into disconnected and smaller areas, so that the strength

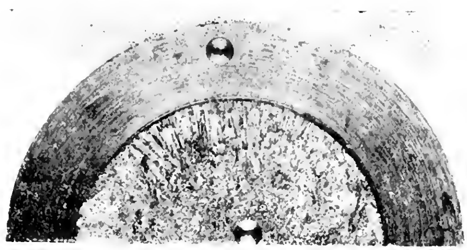


Fig. 7. -Section of Steel Ingot Showing Coarse Crystals (Ingotism.)

and toughness of the metal is very much increased. The more work that is performed, the greater the improvement in strength, ductility and general quality, other things being equal. Ingotism, or a coarse crystalline structure in a cast ingot, is therefore not a necessarily bad feature when it is intended to further roll or forge it, since it becomes obliterated and its evil effects destroyed by such further working.

A coarsely crystalline structure in a forging must not be confused with the structures found in a cast ingot. The ingot crystals may be large, and the crystal boundaries may be relatively weak from the segregation of impurities, and easily rupture or give way under stress. The large crystals sometimes found in forgings, on the other hand, are produced by high finishing temperatures and slow cooling above the critical range.

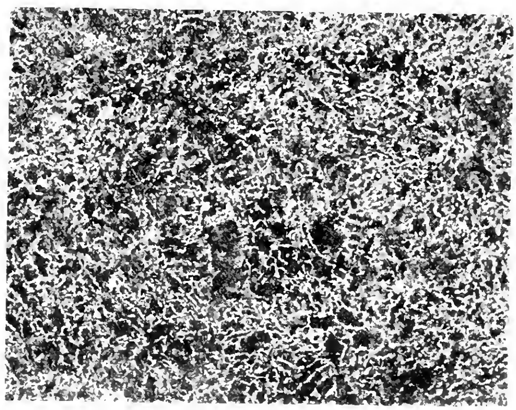


Fig. 8.—Same steel section as shown in Fig. 7, After Reheating, Showing Refinement of Grain.

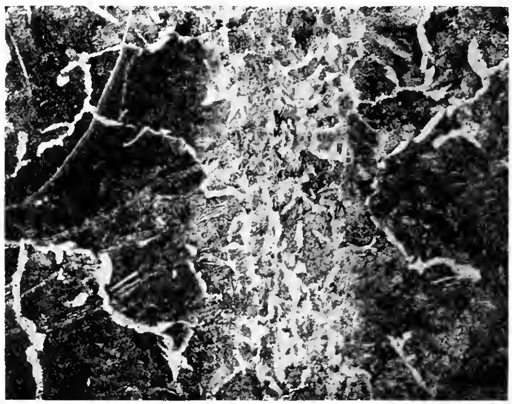
Any segregation of impurities will be broken up and distributed more or less uniformly throughout the metal, so that they will not be concentrated in the crystal boundaries. Fracture will thus take place only after severe strain and will not necessarily follow around the crystals, but may be across them.

Fig. 9.—Section from Steel Forged at too high a Temperature, and Slowly Cooled.

### Segregations.

Segregations may be defined as the local concentration of some of the constituents or impurities found in steel, but the term is usually limited to those of phosphorus, sulphur, manganese, slag and their combinations or admixtures as they exist in the metal. When the steel is molten they remain dissolved in it, and tend to make the metal more fusible, that is, to lower its melting point. But, as explained before, when solidification or crystallisation begins, they are expelled to the borders of the crystals, and may become entrapped between them or become concentrated in that part of the ingot which solidifies last. This is usually just below the bottom of the pipe. Segregations which form around or just below the bottom of the pipes may be of quite large size, but are usually removed along with the pipe when the ingot is cropped. In a fractured surface, when freshly broken, any excessive segregation can be distinguished by its relatively brighter appearance, and silvery lustre. In such a case a further cropping should be made until a fresh fracture shows no such appearance.

When the ingot is rolled or forged the segregations become elongated in the direction of the flow of the metal, and, depending on the original size of the segregate, may be so distributed and broken up as to be practically invisible to the eye and, in fact, may be so small as to have very little effect on the strength or other qualities of the steel as far as its practical use is concerned. The small segregations between the crystals of the ingot after rolling and forging are elongated into fine thread-like lines of impurities and are to be included in the term "ghost" lines, from their white appearance on the freshly machined surface and also from their disappearing when subjected to further machining or even to polishing with emery cloth. They are not usually more than a few thousandths of an inch in diameter, and may vary in length up to a few inches. As found in a forging they are softer than the surrounding metal, and on machining the tool often digs into the steel, and then jumps up again after crossing them, causing a "chattering" of the tool. Figs. 10 to 13.



Figs. 10 and 11.—Sections of Steel Showing Ghost Lines in Rolled Billet, x 90.

T. O. Arnold, D.Met., F.R.S., in a paper before the Institution of Mechanical Engineers in 1915, on "The Cause and Effect of Ghost Lines in Large Steel Forgings," describes an investigation which he made on a large forged steel propeller shaft, which on machining had exhibited ghost lines. He made a very complete series of physical tests and microphotographs, and concluded that ghost lines are little detrimental to the mechanical properties of structural steel, so long as the plane of the stress is at right angles to the direction of the ghost lines; in other words, when the material is in tension, torsion or under alternating stresses.

### Checking or Cracking.

Any irregularity in the heating or cooling of a piece of steel will cause uneven expansion or contraction, and may result in a warping or bending of the metal. In case of a local plane of weakness or segregation of impurities along any one direction, such irregular heat treatment may even cause a check or crack to develop and, if long continued, or on renewed heat-

ing or sudden shock, may result in the crack spreading and enlarging until the strain is relieved. Cracks may be externally visible, in which case they will not weld together again, but will become oxidized and filled with slag and tend to extend in length and depth. A so-called "roke" would possibly be classed as an external crack or check which had become closed in forging, but whose oxidized walls had prevented actual welding of the metal and had appeared as a dark longitudinal line. Internal cracks whose

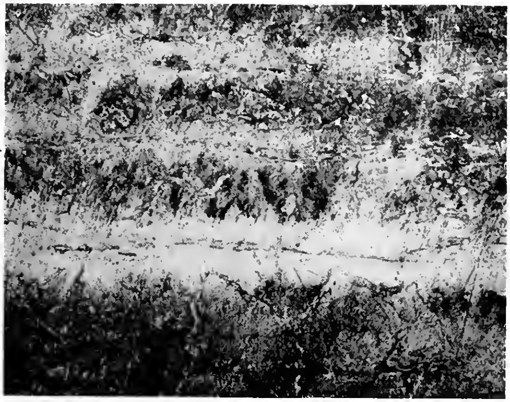


Fig 12.—Same sections is in Fig. 10, Showing Bands Rich in Phosphorus, x 90.

surfaces are clean and bright will usually weld again when subjected to hot rolling or forging. Such metal, however, is not likely to be as strong afterwards and hence the great necessity for the most careful treatment in heating billets before forging and in cooling, so that no strains be set up.

Cracks also develop externally in cast ingots, and in forgings made from them, which are not parallel to the direction of the flow of metal, but are more or less at right angles to it. In cast ingots they usually appear in those containing several adjacent pin holes, and are evidently the result of the "hanging" of the solidifying steel in the mould or from uneven contraction on cooling. The adjoining pin holes present a line of least resistance along which the strain may be relieved and a crack develop. The crack may be hardly visible in the cold ingot to the naked eye, but on heating it preliminary to forging it opens up and becomes oxidized and even filled with slag from the furnace lining. When such an ingot is forged that portion next to the cold die is quickly chilled and the crack remains open and usually becomes larger. Its depth will often extend even beyond that of the original pin holes.

**Seams.**

Seams are external defects, usually longitudinal, and are caused by a folding of the metal in rolling or forging. In rolling a large ingot receives a number of "passes" between rolls each of a smaller diameter

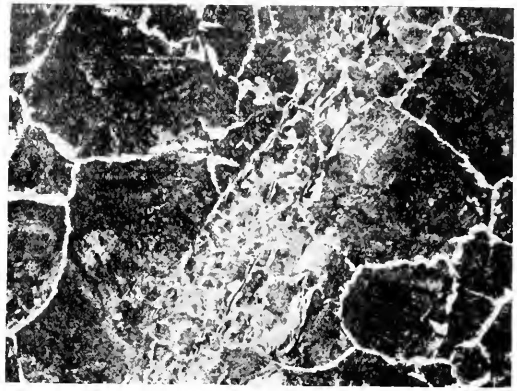


Fig. 13.—Section Showing a Ghost Line in Forged Steel, x 90.

until the required size of bar is obtained. Scale is sometimes rolled into the bar in one pass and breaks off again, leaving a cavity which may be of varying length or depth. The rolls also after constant use become rough, and give rise to corrugations or indentations. Further rolling may cause a folding of the metal in a longitudinal direction, and thus give rise to seams.

Such seams are usually chipped out before the bars are further forged or used, but unless the chip is of sufficient width and depth a seam will still be obtained. In forging, also, a seam may be obtained through dirt or scale being forced into the steel or from a rough worn die. The walls and edges of such seams are always oxidized and will not weld together, and forgings in which they occur to such a depth that the further machining operations will not get below the seam have to be scrapped.

---

The following discussion took place after the presentation of the paper:—

MR. McFARLANE expressed the opinion that many so called ghost lines were really shrinkage cracks due to rolling and cooling, and that the true ghost lines, or phosphorus segregation, would have a tendency to follow the inside bore.

MR. DAUNCEY stated that three principal theories were advanced to account for "ghost" troubles, and he was of the opinion that no one of these could be accepted to the exclusion of the other two. In answer to one of the previous speakers if some small portion of foreign matter became trapped in, or near, the outer wall of an ingot that might easily prove the starting point for "ghost" trouble. He had, however, frequently seen superficial imperfections that were not "ghost" but micro-crack troubles. These may have been caused by minute surface defects on the original billet, or may have been due to working stress, or cooling conditions. His Canadian experience led him to believe that the tendency

was to blame steel when the trouble was frequently caused by improper heat treatment, or working conditions. Mr. Werner had given them a most interesting and instructive paper and had shown many ingenious schemes and devices for improving raw steel, but he (Mr. Dauncey) was a strong advocate for keeping furnaces and product in good shape for seeing that ladles were thoroughly dry; that moulds were designed in accordance with known cooling conditions, and that the metal was given time to set before being roughly handled. Close attention to these details would be found far more satisfactory than any reliance that could be placed upon deoxidizers, or dope of any kind.

LIEUT. PATERSON stated that the authorities at Woolwich had made hydraulic tests on shells with ghost lines, and found that they were apparently satisfactory. The last word we had, however, was that after seeing the results of firing proof of these shells, they considered it dangerous to accept certain types of them.

DR. PORTER congratulated the Association on Mr. Werner's extremely good address. He stated that operators have turned to the use of dope rather than to careful handling. That greater care and constant study were necessary in regard to temperature, handling, and shape of mold so as to localize defective portions in as small a part as possible of the ingot.

DR. STANSFIELD suggested that anyone having questions to ask might write the secretary for information.

MR. ROAST asked Mr. Werner if manganese sulphide inclusions, commonly called slag inclusions, always accompanied ghost lines. Mr. Werner stated that while manganese sulphide inclusions were commonly found in ghost lines many ghost lines examined showed no inclusions of this nature; also manganese sulphide inclusions were not necessarily accompanied by phosphide segregations.

MR. ROAST, when moving a vote of thanks, called attention to Mr. Werner's statement that much of his material had been got from books. The paper, however, showed a great amount of original research done by Mr. Werner.

MR. ROBERT JOB presented an interesting series of slides showing "Transverse Fissures in Rails," illustrating the way in which defects in ingots affected the structure and physical properties of rails rolled from them.

## AMERICAN CLAY FOR GRAPHITE CRUCIBLES.

The manufacture of plumbago crucibles has been greatly affected by the present war. The two important ingredients in these crucibles are graphite and plastic clay. Graphite being a lubricant, is difficult to bond and requires a clay of high plasticity and adhesiveness with a high drying and heat shrinkage.

As pointed out by Mr. McNaughton of the Joseph Dixon Crucible Co. last fall in his paper before the American Institute of Metals on the crucible situation, all of the clay for crucible purposes, and 95 per cent. of the plumbago was imported. The clay used came almost exclusively from Klingenberg, Germany. Shortly after the war started Germany prohibited the exportation of this clay, and while crucible manufacturers had about a year's normal supply on hand they found that the demand for crucibles was rapidly increasing and their supply would last them a much shorter time.

The crucible makers hence warned their customers that the quality of crucibles made from domestic clays would be for some time an unknown quantity until sufficient service tests had been made.

Laboratories have been called upon for testing possible clays, and several clays which give promise have been found. It is usually two or three months, however, by the time a crucible is made, using this clay, and thoroughly tested out.

One interesting clay which has been produced is the so-caled K-10 synthetic clay, developed at the Kraus Research Laboratories in New York, and originally marketed by Chevalier & Tully, of Baltimore, Md., but now handled by the Johns-Manville Co., who plan to market it on a large scale.

This clay is produced by making extractions from various clays, etc., which are so combined as to produce a fine-grained, highly plastic refractory mass having excellent bonding power. The shape of the grains must be such that the clay when moistened and dried will have high mechanical strength. Modulus of rupture tests made on this and other clays follow:

| | Modulus of Rupture Lb. per Sq. In. Raw | Mixed with 80% Non-Plastic Material |
|---|---|---|
| K-10 | 552 | 518 |
| Klingenberg | 374 | 381 |
| Mississippi | 507 | 168 |
| H. & W. | 310 | 67 |
| Illinois | 156 | 212 |

The following qualities are considered requisite for a good crucible clay: plasticity, adhesiveness, raw strength, density at low temperature, chemical balance, resistance to metals in fusion, high melting point, high shrinkage on drying, high shrinkage on heating and low coefficient of expansion.

## EXTRACT FROM POPULAR SCIENCE, MARCH, 1918.

### Steel Wheels Are Becoming Popular.

The tendency to substitute steel for wood in the manufacture of wheels for automobiles and heavy trucks is not due to any desire to economize in the cost of the wheels, but is largely the result of the scarcity of good wood. In Europe, the wooden wheel has long been replaced by the steel wheel on trucks.

The most widely used wheel in England to-day is made from sheet steel. It is stamped in two parts. These are afterward welded together by an acetylene flame. The finished wheel looks almost exactly like a wooden wheel. There is an immense length of weld, however, which follows the mid-section of each spoke, so that this type of wheel is not considered a very good manufacturing proposition.

From three to six bolts are used, according to the size of the wheel. These have cap nuts. The outer nave plate is a loose fit on the hub, so that the wheel can be pulled off easily when the nuts are removed. The wheel can be supplied with a demountable rim if desired, but there is very slight demand for such rims in England.

# Steel Treating Research

We have received the sixth number of Vol. I of the Proceedings of the Steel Treating Research Society from their headquarters at Detroit, Mich. It contains a reference to a prize that is being given by Sir Robert Hadfield, who states, "I am trying to get interest aroused so that better methods may be introduced for determining high hardness (super hardness) that is 580 Brinell and upwards, where the material becomes so hard that it will scratch glass." It may be acknowledged that the Brinell method enables high hardness to be determined with reasonable accuracy, but that the time necessary to do this is considerable, and almost prohibitive in large works, where thousands of determinations are required weekly. The Scleroscope is also useful in application, but does not give sufficient accuracy. The dificulties surrounding this class of work may be of three kinds, the time necessary to make an accurate determination, the trouble in maintaining a definite load without any fluctuation, and the more marked difficulty of making correct measurements of the indents produced. The nature of the operation seems to preclude the possibility of greatly expediting the time necessary for a reading, but a load can be maintained without an appreciable fluctuation if proper precautions are taken, whilst a higher magnification of the impression would seem to be the solution of the measurement trouble. The competition is now open, and all information will be supplied upon application to the Secretary, Steel Treating Research Society, Book Building, Detroit, Mich.

Mr. R. B. Lincoln's paper on "Thermo Electric Pyrometers" is also included in these proceedings, and contains a mass of useful and concisely defined information upon various methods of accurately reading high temperatures. Most types of instrument used for this class of work are enumerated, including calorimetric, radiation, optical, and the thermo couple. The author summarizes the field of usefulness of each type and claims that the use of nickel chromium is for the first time published in his remarks. The Seger cone is also dealt with, more especially as regards its usefulness in firing refractories, but sufficient importance is not attached to this method of regulating temperatures. The writer has successfully used them for annealing, normalizing and case hardening steel, and also for malleableizing black and white heart malleables. With large furnaces it often happens that difficulties arise in securing an accurate temperature reading of some particular spot, and in such cases the cones will render valuable assistance. They are capable of reading temperatures with a variation of about 20°C. from 590°C. (1094°F) up to 2000°C. (3578°F.), and as originally made were composed of various mixtures of quartz, feldspar, marble alkalis with certain pure clays. Later methods have adopted mixtures of either silica, or boric acid, or both, and the bases soda, potash, lime, alumina, and ferric oxide. Mr. Lincoln cites the details of much instructive and interesting experimental work, and the paper as a whole is of particular value to those engaged in the forging, annealing, and heat treatment of steel.

Sir Robert Hadfield's name appears again in the Steel Research Society's proceedings, for he is responsible for a translation of the Report of the German Iron and Steel Institute. The meeting was recently held in the Municipal Concert Hall at Dusseldorf, and it would be interesting to know by what means the translator secured a copy of the report. It could hardly have been the intention of German authorities to have it translated for reading abroad, for it contains very freely expressed opinions, and clearly indicates certain anxieties as to the future. It would appear that the U-boat warfare turned on the Emperor's decision, and that for some time a waiting policy prevailed. Apparently this was only decided upon as a last resort. Germany apparently fears she is to lose or have her trade seriously crippled, and realizes that she must so organize her empire as to be independent of outside supplies. It also appears to be admitted that she has become aware of the fact that in the future she will not be allowed to prey upon other countries' trade. A shortage of essential materials is acknowledged and the providing of substitutes urged as a national necessity. A list of those present from the Army Service and members of the Institute is given, and the chairman, Dr. F. Springorum, delivered his opening address in which, after welcoming the many visitors, he said, "Last, not least, I welcome our own members who, nearly all of them, are directly or indirectly either bearing arms, or helping to forge them for our country. I see among them with special gratification our highly esteemed honorary member Dr. Krupp von Bohlen und Halbach." The Institute has a membership of 6,152, and of these 41 have been decorated with the Iron Cross of the second and of the first class, 320 with the Iron Cross of the second class only, and 66 have had other Orders bestowed upon them. As regards the general activities of the Institute, the chairman dealt with the use of blast furnace slag for concrete, and in connection with this an interesting innovation is cited. The Institute appointed a commission to study the applicability of blast furnace slags for concrete; this commission reported favourably, but as a check upon their decisions a department was organized for the investigation of bad results obtained in the use of blast furnace slag, to which any such cases should be reported. Other matters dealt with included the saving of manganese, steel-works tar, production of homogeneous iron (mild steel), construction of privately owned rolling stock, gravimetric methods of analysis, grooving of rails, thick plate rolling mills, etc. Dr. Springorum also makes the following remark: "The war has intensified the need, already felt before, of closer co-operation of the German techni-

cal societies and preliminary negotiations have led to a combination of the technical societies into a German Union of Technical-Scientific Associations." Again he says: "We shall, after the war, far more than hitherto, have to depend upon ourselves, and to rely on our own strength. Accordingly the demands upon us will be enormous." In the final quotation we shall make Canada may read a useful object lesson. "Industry will only be able to meet them (after war conditions), by strenuous work, and will, above all, have to study better utilization of fuels, and the further perfecting of the metallurgical processes. Co-ordination between metallurgical practice and metallurgical research will in future be imperatively needed." In our next issue we may again refer to this report, for space now prohibits further discussion, whilst several interesting points remain untouched.

The Steel Treating Research Society is to be congratulated upon the excellence of its publication upon the fact that it has interested a man of Sir Robert Hadfield's attainments, and upon the vitality of its meetings and organization.

At the annual meeting of the Driver-Harris Company, Harrison, N.J., Leon O. Bart was elected treasurer and a director of the company. Mr. Hart is a member of the American Electro Chemical Society, and also the American Society of Electrical Engineers.

# Thomas Cantley

In nearly every case when the biographical sketch of a man is written the writer chronicles the fact that he was born in some little out-of-the-way place and later as ambition arose within him he moved to a larger field where there were greater opportunities for his advancement.

In the case of Lieut.-Col. Thomas Cantley this does not hold sway. Thomas Cantley was born, educated and has lived his entire life in the little town of New Glasgow, N. S. Instead of wandering away to the larger fields of opportunity which might be found in the cities of Montreal, Boston or New York, he preferred to stay in his native town and make a big place for it and himself. To the casual onlooker there were no outstanding differences between young Cantley and the other boys who attended the public school, did their allotment of chores after hours, and fished, hunted and roamed the woods on Saturdays, and yet underneath the quiet exterior of this steady going lad there were the stirrings of ambition and an innate desire to dominate his surroundings.

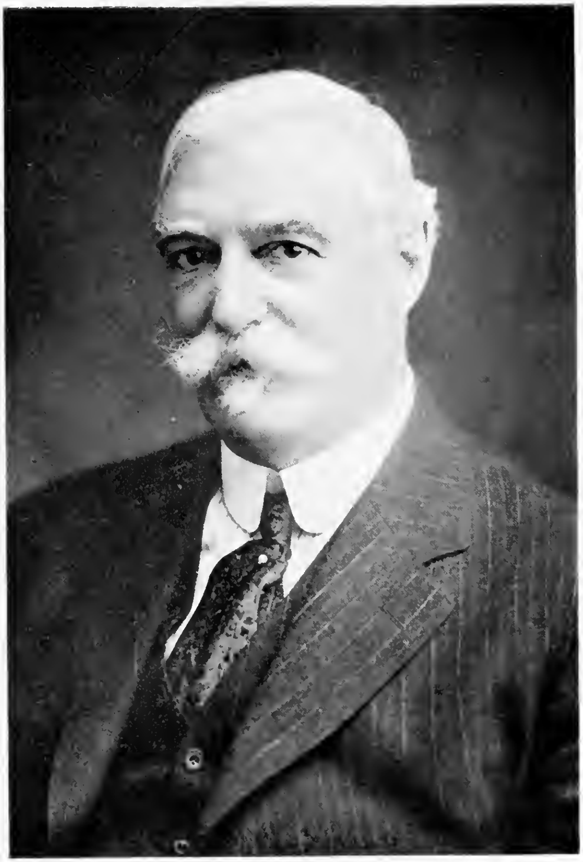
As a lad in his teens Cantley decided that the telegraphic key was the Sesame which would open the world's store houses. Perhaps it was chance which prompted young Cantley to learn telegraphy, but more likely it was a vague inarticulate desire to be brought into touch with the bigger world of affairs which he dimly realized lay beyond the little world he knew in New Glasgow. Whatever the reason for choosing this field he took a means which has been popular with many of the big men of the past generation. It was through the telegraph key that Thos. A. Edison first earned his living and was started on his great inventive career. The same means were also employed by the late Sir William Van Horne, perhaps the greatest railroad man this country has ever known. In a measure the experience young Cantley obtained through his key board satisfied him in regard to the outside world. Through it he learned that far off fields are not always green and that while youth may "yearn beyond the sky line where the strange roads go down," there is not always a silver cup at the end of the rainbow. As a telegraph operator young Cantley kept both eyes and ears open, studied hard, carefully hoarded his meagre savings and then a little later launched out in business on his own account. This was short lived, however, and while still a young man in his early twenties he decided that in unity there was strength and cast in his lot with the small and struggling Nova Scotia Steel & Coal Company.

A few years before this two Scotchmen, McKay and Fraser, blacksmiths by trade, had decided to enlarge the walls of their blacksmith shop and go into manufacturing on a larger scale. It was a very modest beginning and the most sanguine optimist connected with the concern never dreamed that a third of a century later the little blacksmith shop would have grown into one of the foremost iron and steel manufacturing plants on the continent. The men with whom Cantley associated himself were men of vision and possessed all the tenacity and shrewdness characteristic of the Scottish race. The enterprise they undertook to finance and operate called for courage of the highest order. The little town in which they worked was far from the beaten track of the world's highways. Manufacturing was an untried experiment in the Maritime Provinces. Many wise people doubted the possibility of success arguing that if it had been a profitable enterprise others would have taken it up long ago. However, the men back of the Scotia Company were determined to develop the latent resources of that district. The great iron ore reserves and the coal areas which had been almost untouched appealed to their imagination. In vision they saw the little blacksmith shop with its one forge replaced by huge buildings with smoke stacks towering against the sky line, with open hearth furnaces and electric smelters replacing the hand forge, with shipbuilding plants, car shops, and various other subsidiary concerns employing thousands of men. They were handicapped through the lack of shipping facilities, by shortage of labor, through the want of technically trained workmen and by being located in an unknown and out of the way place, but looked upon all these difficulties as an additional incentive to hard work.

When young Cantley joined the Nova Scotia Steel

COL. THOMAS CANTLEY, New Glasgow, N.S.

Member of Executive Committee, Iron & Steel Section, Canadian Mining Institute.



ROBERT HOBSON, Hamilton, Ont.

Member of Executive Committee, Iron & Steel Section,
Canadian Mining Institute.

& Coal Company he occupied a very minor post, but filled the position in a thorough and capable manner and soon mastered all the details of the slowly growing business. In turn he was the Company's telegraph operator, its bookkeeper, its salesman, its manager, president, and to-day, chairman of the board of directors. The third of a century he has spent with the company has been characterized by steady and persistent progress. Discouragements innumerable there have been, times when the financial outlook seemed overcast, when the markets seemed circumscribed, and when the whole future seemed hopeless. He and his associates never lost heart. They cheerfully carried the financial and industrial burden knowing in their heart of hearts that some day the tide would turn and that they would come into their own.

In many respects the bare biographical outlines of a man's life are not of great interest, except perhaps in the case of our self-made men where each step in their advancement is a mile post to those anxious to better themselves and consequently serve as incentives. The case of Mr. Cantley well illustrates this point: Born in New Glasgow in 1857, he started out to earn his living as a messenger boy for the Western Union Telegraph Company at an age when most boys are still in the public school. From a messenger he became a telegraph operator, then as was characteristic of him in later days he saw the possibilities of building a telegraph line to an out-of-the-way coal mining station. This desire to make the most of his opportunities and better himself led him, a few years later, to go into the mercantile business. He entered into partnership with Mr. J. D., later the Hon. J. D. MacGregor, Lieut.-Governor of the Province. After a few years in business the partnership was dissolved and Mr. Cantley joined the Nova Scotia Steel & Coal Company. That was away back in 1885, or a third of a century ago. From sales manager he became secretary of the Company, then associate manager, later he became manager, then director, then general manager for sixteen years; second vice-president, president, and finally chairman of the board of directors.

Even if these successive steps in the career of Mr. Cantley had not meant a corresponding extension and growth of the Company they would have been in themselves significant. As it is, however, these thirty-three years were characterized by untiring efforts on the part of the subject of this sketch, endeavors which met with a very large measure of success.

As a matter of fact it is doubtful if there has been a man in Canada who has done more research and more constructive work in connection with any industry than that performed by Mr. Cantley. When he joined the company it was just emerging from the blacksmith's shop stage, but a whole vista of possible development lay before the small company. In order to take the fullest possible advantage of its resources and to make no serious mistakes Mr. Cantley not only inspected and thoroughly familiarized himself with the coal and iron ore reserves possessed by the company but he visited every country in Europe, studied processes of coal and iron mining, learned of the latest methods of smelting ores, processes of forging steel, sought new markets, secured shipping facilities, and in general acted as a commercial traveller at large for the Corporation. Among other countries he visited England, Scotland, Wales, Norway, Sweden, France, Germany and Austria selling iron ore and coal to these countries and investigated their particular process of manufacturing iron until he made himself an authority on iron and coal mining and the manufacturing of steel. Among other things he carefully studied the process of fluid compression and hydraulic forging of steeel. Later he installed a system of fluid compression at Sydney Mines and at New Glasgow a hydraulic forging plant, regarded as one of the most complete in the world. Between times when rushing back and forth to Europe he constructed large plants at New Glasgow, purchased the "Old Sydney" coal deposits and laid broad and sure and deep the foundations for the present mighty corporation.

Col. Cantley has been a pioneer in many lines of industry; not only has he led the way in the process of manufacturing iron and steel, in new methods of coal mining, etc., but as the parent country grew he branched off into many different side lines. A half century ago Nova Scotia was a great wooden shipbuilding centre, but with the introduction of steel ships the industry languished and died. Col. Cantley determined to revive the industry and some years ago started the building of steel ships at his New Glasgow plant. To-day shipbuilding is a popular industry and ships are being constructed in scores of yards, but Thomas Cantley was the pioneer of this industry. Again his was one of the first companies to establish a car manufacturing plant; a subsidiary, the Eastern Car Company, has to-day grown into a very important concern. When the war broke out and Britain turned to Canada for shells and munitions the Government was almost paralyzed and were at their wits end to know what to do. Under the leadership of Thomas Cantley a start was made in the manufacturing of munitions, although up to that time a shell had never been made in Canada and not one manufacturer in a thousand had ever seen a shell, let alone try to make one. In shell making the Nova Scotia Steel & Coal Company performed a notable part. Mr. Cantley was made a member of the Shell Committee and given the title of Honorary Colonel in recognition of his services.

Col. Cantley is a member of the Iron and Steel Institute of Great Britain, the American Institute of Mining Engineers, a member of the West of Scotland Iron and Steel Institute, a member of the Electro-Chemical Society and of the Canadian Mining Institute. From his membership in these societies it is easy to see his hobby in life. In brief this might be characterized as work and an innate desire to familiarize himself with the various phases of the iron and steel industries with which he became associated a third of a century ago. If anyone would seek a monument for Col. Thomas Cantley they have but to look at what he has accomplished in his native town and native province.

J. C. ROSS.

# Robert Hobson

There is an American saying which goes somewhat as follows: "From shirt sleeves to shirt sleeves in three generations." It is quite apparent that this is not always true. In the case of the Hobsons there is no sign of any lapse, but on the contrary the proverb might well be altered to read "Like Father, like Son."

A few months ago Joseph Hobson, C.E., Engineer in charge of the Sarnia Tunnel, died at an advanced age. He was long regarded as one of the foremost engineers and railroad men on the continent, and his passing meant the elimination from railroad construction work of one of the pioneer builders in this country.

His son, Robert Hobson, started out in life to follow in his father's footsteps. For a few years he was actively engaged in railroad work. Later he decided to go into manufacturing, and in that line has achieved almost as great a name and place for himself as his father did in the railroad construction world.

Mr. Robert Hobson became connected with the Hamilton Blast Furnace Company some twenty odd years ago. He little thought at that time that he would one day be head of one of the largest steel manufacturing corporations on the continent. Young Hobson was a pioneer in that effort, for the company with which he was connected was the first producer of pig iron in Canada. After remaining with them for three years he became General Manager of the Hamilton Steel & Iron Company. A dozen years later he joined the newly formed merger of various steel plants known under the name of the Steel Company of Canada, Ltd., as General Manager. In 1916 he was made President of the Company, whose annual report issued a few days ago showed gross earnings for the year just ended in excess of $6,000,000.

Such, in brief, are the outstanding land marks in the business career of Robert Hobson, but by no means covers the whole range of his activities.

Although he is one of the foremost steel men in the Dominion he has also found time to interest himself in a large number of other interests. Mr. Hobson is a Director of the Bank of Hamilton, a Director of the Landed Banking & Loan Company of Hamilton, the Tuckett Tobacco Company and the Canadian Locomotive Company, as well as being less actively associated with a large number of other corporations. He is also an ex-President of the Canadian Manufacturers' Association, a Director of the American Iron & Steel Institute, and a member of the American Institute of Mining Engineers, the Canadian Mining Institute, and a member of the Honorary Advisory Counsel for Scientific & Industrial Research. Mr. Hobson is a member of a dozen or more clubs, but is not in any sense of the word a club man, except as these can be used for business purposes.

In very many respects Mr. Hobson is a pioneer in Canadian manufacturing activities. Years ago Andrew Carnegie saw fame and fortune in the first iron bridge built in the United States and allied himself with iron with the shrewd canny instincts of a Scotchman. Carnegie put his all into the steel manufacturing business and built bridges, steel for sky scrapers and other products until he became the greatest steel magnate in the world's history. In like manner Robert Hobson saw the possibilities of pig iron manufacture, and industries relating to that basic product. To-day his company takes the raw pig iron and turns out "57 varieties" of steel products, from tacks and nails to wire fences and steel plates. One of the secrets of Mr. Hobson's marked success in life is due to his ability to pick able associates. In early life he saw that no business could really become great as a one man concern. Keeping this in mind, he has associated with himself the ablest men he could find, and much of the success which has followed the Steel Company of Canada is due to the live wires with which Mr. Hobson surrounded himself.

Mr. Hobson is another of the growing list of Canada's business men who have found their opportunities at home. In the old days it was a popular thing for a young man possessed with any ambition to cross the Line and seek his fortune, in the United States. Mr. Hobson is an Ontario boy, born at Berlin, now (Kitchener). Instead of going far afield he decided that first the railroad and then the manufacturing presented as many opportunities in Canada as in the United States, and he never travelled far from his native place. When difficulties presented themselves he resolutely faced and overcame them just as his father looked upon mountains to be tunnelled, rivers to be bridged, and other natural obstacles as engineering problems to be overcome in his railroad work.

In like manner Robert Hobson has overcome financial, economic, labor, shipping and other difficulties, in some cases obstacles so pronounced as to daunt and discourage the ordinary business man. To-day he is one of Canada's big captains of industry, a position he attained entirely by his own efforts, and not by any system of pull.

---

# Fahy Permeameter for Magnetic. Mechanical Analyses of Iron and Steel

(Reprinted from "Machinery," February, 1918.)

Research work done abroad and at the U.S. Bureau of Standards has shown that the magnetic properties of iron and steel afford a most valuable index to the structural conditions existing in such materials, which is of special importance in those materials intended for use where strength or cutting properties are the essential factors. Not only do the initial processes of manufacture affect the magnetic characteristics,

but subsequent heat-treatment also. Therefore, the magnetic test offers means of examining materials, tools, etc., during and after manufacture, without injuring or marring them, with a view to predetermining their mechanical performance. It also presents a method of investigating the "exceptional tool" or product, looking toward its routine duplication. In nearly every plant it happens that—by a combination of circumstances—a tool of remarkable quality, otherwise not distinguishable, is sometimes turned out which stands up far better than the average run of the product. It is, of course, important to obtain data to enable duplication of this high quality, and by the method of "magnetic mechanical analysis" we are in a position to ascertain the characteristics of the remarkable product, so that a basis is created for its exact duplication. The method of "magnetic-mechanical analysis" is based upon the fundamental fact that "there is one, and only one, set of mechanical characteristics corresponding to a given set of magnetic characteristics, and conversely there is one, and only one, set of magnetic characteristics corresponding to a given set of mechanical characteristics."[1] The International Association for Testing Materials, the American Society for Testing Materials, the U. S. Bureau of Standards, and a number of private investigators are actively engaged on this important work, so that the science of properly correlating the underlying factors will surely make rapid progress in the near future, especially since accurate and convenient apparatus has now been developed to permit the practical application of this method of analysis in the industries. There are many advantages of "magnetic-mechanical analysis" which are of great importance. The material actually entering into the construction of the finished product and, in most cases, the final product itself can be subjected to the test without suffering the slightest injury. The various methods of testing now largely used (chemical, microscopic, hardness, tensile, impact, etc.) are either destructive or local surface tests. As Dr. Henry M. Howe says:—"Our tests destroy the part tested. That is a crude state of the art of testing. A wholly different line of testing from that now employed is opened by these magnetic investigations; that is to say, the reaction of the material to forms of energy which have no permanent effect on the material itself. . . . I do believe that we need radically different methods of testing; that our present methods are those of a crude, ignorant age, and will give way in time to radically different methods of testing which determine the reaction of the substance to forms of energy which do not injure the substance." Besides the point of destruction emphasized by Dr. Howe, the important question of "sampling error" enters into all the old methods of chemical and physical tests. As the science of testing stands now, we are pulling to destruction a bar of steel or piece of wire and presume that the rest of the material under investigation is exactly the same quality as the small specimen tested. We cut off a piece of steel for observation under the microscope and relieve the internal stresses in the metal, which are an important factor in the investigation. We press a small steel ball into a spot of a forging, casting, etc., and assume that this gives us the hardness of the entire mass.

Another important feature of the magnetic-mechanical test is that it shows quite clearly differences in the mechanical properties of steel, where the other methods of test fail to indicate them, and where practice has shown that such differences do exist. Two pieces of steel may have the same "Brinell hardness," for instance, and still possess entirely different mechanical characteristics. This point was shown by R. P. Devries, who states: "I wish to call attention to three specimens of steel, one annealed and two in the hardened condition. These pieces were tested by means of the Brinell hardness test, notch bar impact and the Martens scratch test. The tests easily differentiated between the annealed and the hardened specimens, but did not distingnish between the two hardened specimens. The "B-H" (permeability) curves for these specimens indicate that by differentiating between the annealed and the hardened state the magnetic test also discloses considerable differences between the two hardened specimens which the mechanical tests do not show." The magnetic-mechanical test is not restricted to work in the laboratory. Products like tools, saw blades, drills, ball bearing races, milling cutters, etc., can be subjected to routine tests in the plant, and in case some of these show distinct differences in magnetic properties against the average run, it is safe to assume that something is wrong with their mechanical properties, so that "seconds" can be easily separated and the quality of tools of established trademark can be at all times fully maintained. Among the many other steel products which readily lend themselves to this method of test are files, knives, drill rods, wires and wire ropes, springs, steel balls, plates, sheets, strips, etc.

This for magnetic-mechanical analysis apparatus is of considerable importance at this time for testing the wires used in airplane construction. Not a "specimen" of the material is subjected to the test, but the wires and cables actually entering into the construction of the planes. The slightest lack of homogeneity or otherwise invisible defects in the stranded wires are clearly shown up and danger is thus prevented. Similar tests can be applied to elevator and hoisting cables; in such cases the apparatus is mounted permanently and defects can be detected before accidents happen.

The main reason why this important method has not found considerably wider practical application heretofore was the difficulty in the operation of the instruments which had been available for conducting magnetic tests. Considerable progress was made by the development of the "Fahy" permeameter, fully described in Scientific Paper No. 306 of the U. S. Bureau of Standards, Washington, D.C., which has already found application in the industry for conducting magnetic-mechanical tests. Further progress has recently been made in the design of such apparatus by the development of a still simpler and just as accurate permeameter requiring no compensation, and of a new type of sensitive galvanometer—similar to the portable instruments used in pyrometry—so that any metallurgical and mechanical engineer or assistant will be able to make accurate determinations. This new line of magnetic testing instruments will also include a very accurate and convenient outfit for testing permanent magnets, such as are used in magnetos, etc. These instruments are being sold by Herman A. Holz, Metropolitan Bldg., New York City.

# Hamilton and the Iron and Steel Industry

Hamilton is called "The Birmingham of Canada," and claims to stand in the same relation to the Dominion to-day that Pittsburg does to our neighbors to the south of us. According to the latest statistics available, there are in this city about 415 manufacturing institutions covering an immense range of industries. As nearly as we can ascertain, somewhat over 200 of these are in manufacturing buildings or plants of their own, the remainder utilizing lofts, stores or other premises of one kind or another.

Of these 415 industries, about 100 are in the iron and steel business or in work so closely allied to it that they can fairly be included in the subject under discussion. Of the remaining manufacturers, a large number serve the iron and steel trade. The cotton and woollen industries claim a fair amount. Foodstuffs and confectionery are well represented and the ever present breweries are still doing business. Tobacco, too, finds quite a stronghold in Hamilton, besides a host of miscellaneous industries, as shoe polish, tungsten lights, etc., etc. But few would question the statement that the iron and steel industries quite outclass any of the others or indeed it might almost be said all the others put together. It is the iron and steel industry that has built up Hamilton. Figs. 1, 2 and 3 show the population, assessment and bank clearings, building permits and customs collections. Speaking generally, these curves show the trend of the iron and steel industry in Hamilton.

The 100 iron and steel industries may roughly be divided as follows:

| | |
|---|---|
| Basic Iron and tSeel Product (not including Iron Foundries), i.e., product from which others are produced | 7 |
| Iron Foundries | 11 |
| Fencing, Wire Goods and Engines | 10 |
| Boilers, Agricultural Implements, Cars, Elevators, Etc. | 17 |
| Hardware and Building supplies | 14 |
| Sundry Metals and Electrical Goods | 17 |
| Tools, Machines, Etc. | 25 |

These divisions are necessarily very rough and arbitrary as many firms cover more than one line indicated above. It must be remembered that among the above are the largest of them employing several thousand men apiece.

Naturally, the question arises, why should Hamilton claim such a large number of the iron and steel industries? How is it this city forms such an important centre in this most important trade? At Birmingham we have coal fields and iron mines in close proximity with an almost unlimited market within easy reach. Much the same conditions apply at Pittsburg, but how is it Hamilton can even begin to claim a place with these other famous cities?

No raw materials for the iron or steel business are to be found anywhere near the locality. Iron ores for smelting are mostly brought from the ranges to the South of Lake Superior. (The Canadian ores are very little used, they are too hard or high in sulphur.) This is all brought down the lakes in the summer by boat to Port Edward on Lake Erie. Here it is unloaded at the wharves of the Steel Co. of Canada and brought to their Hamilton plant via Grand Trunk Railway, where it is unloaded off stock trestles, and piled up for winter use. In a normal year about a million and a quarter tons of ore are brought into the city in this way, a distance of about a thousand miles.

Coal and coke come largely from the Pittsburg district. With both blast furnaces running, the Steel Company of Canada uses 450 to 500 cars of coke per month. A glance at a map shows the significant fact that Hamilton is almost due north of Pittsburg. The coke is brought in daily via T. H. & B. Railway. The ferry across Lake Erie makes this trip about as short as is possible to any Canadian city, yet the journey is about 200 miles in the summer, using the ferry and some 250 or more when the trains must go round the end of the lake. Limestone for fluxes, it is true, comes from nearby, some from Dundas, only about five miles away, and some from Woodstock, about 45 miles off.

With these facts in view, it is evident we must look for further reasons to find the secret of Hamilton's supremacy in this trade. Perhaps the first of these is its excellent position as a distributing centre for finished product. Situated at the extreme west end of Lake Ontario it is the natural centre of supply for the rich and thickly populated districts in the south-western part of Ontario. Here, right at its very doors, is a large market for agricultural implements, electrical goods, builders' supplies and hardware of every description. Here within a radius of 40 miles is a population of (1911 census) over 162,000, or about 10 per cent. of all Canada, over 105,000 more than the number within a similar radius of any other city in Canada.

But Hamilton's markets are not limited to south-western Ontario. If we look again at a map it will be seen that Hamilton is just about centrally located between the Prairie and the Maritime Provinces. It is also well located for northern trade to the Cobalt and Porcupine districts. All summer long freight boats plying between Montreal and Fort William may be seen taking on their loads of pig iron, steel angles and bars, track equipment, etc., at the Steel Co. of Canada, or being loaded down with agricultural implements from the wharves of the International Harvester Company or Oliver Plow Works. Again we can see the tractors, we have heard so much about lately, being shipped away from Sawyer & Massey's, together with quantities of other farm and road implements that they manufacture. All this, together with an endless variety of other steel and iron articles are for shipment to the great Prairie Provinces or to start their journey through Lake Ontario and the St. Lawrence to Eastern markets. There is almost nothing you can think of that would not be found in these Hamilton cargoes. Engines and boilers, scissors or carpet tacks, stoves or stove polish, with an almost unlimited "et cetra" are all stowed away by the different Hamilton shippers.

If we turn to structural steel, we find the name-plates of the Bridge Works Co. on almost every class of steel structure in every province of the Dominion from Nova Scotia to British Columbia, and indeed

lately many carloads of their products have been finding their way across the international border to the south of us. Or, again, we see whole trains of brand new cars for every railway in Canada, to say nothing of France, India, and other foreign countries, built by the National Steel Car Co.

How is this? What is the secret of it all? Surely it is the central position Hamilton holds. Truly for manufacturing purposes it is the hub of the Dominion. But we need not look far for other reasons for Hamilton's share in the steel and iron industries. Excellent shipping facilities, both by rail and water are a great boon to the city. Easy access to most of the large American roads by way of Niagara or Detroit helps American trade. The T. H. & B., C. P. R., and Grand Trunk are all in the city (some people think too far in.) The Can. Northern has a right of way picked out and so may be looked for at some time if conditions warrant its construction. With the completion of the Welland Canal (we can hardly say it is in sight) heavy western shipments will be greatly helped. Also iron ore will come direct from the mines to the blast furnaces by water, and much expense will be saved. This will put Hamilton in an even better position commercially than it holds to-day.

Perhaps the next item to consider is electric power and natural gas; the proximity to the Niagara River gives Hamilton exceptionally cheap power rates. For over twenty years the Dominion Power and Transmission Co. has brought power from Decew Falls, a magnificent development with an effective head of 265 feet. This is used for electric powers, manufacturing purposes, house lighting and, until recently, street lighting. The total power supplied to manufacturing industries by the D. P. & T. Co. last year, was about 30,000 K. W.; of this amount 16,000 was used by companies in the steel business alone. About 4,000 was used by companies in the agricultural implement business. Much of the remaining 10,000 was used by the Canadian Westinghouse Co. and similar industries which might really be classed as iron and steel. The Steel Company of Canada is their largest customer. Fig. IV. shows the power used by this company for the last five years. About 1913, the D. P. & T. Co. ran a special high voltage line to the Steel Company, and they exclusively supply electrical power to this immense concern. The Dominion Power and Transmission Co. recently put up a splendid steam generating station to take care of peak loads and bad weather conditions. This has made their service remarkably good. The fact that this company tapped Niagara Power before it reached Toronto undoubtedly helped to draw manufacturing concerns to this city rather than to our larger neighbor.

Natural gas has been piped to this city for a number of years. It is largely used in heating furnaces, etc., in different manufacturing plants in the city, and also is much valued for domestic use. Unfortunately the demand is considerably above the supply, but in spite of this, it has played its own part in the development of industries in this city.

The last enterprise (though by no means the least) to enter the field of light, heat and power is the Hamilton Hydro Electric Power Development. This is part of the same scheme that provided Hydro Power from Niagara to so many towns and cities in this part of Ontario. Though it is not much over six years since this power came on the market, its growth has been most remarkable. Fig. V. is a curve showing the growth of power connected by the Hamilton Hydro Electric with various metal industries in this city. This growth would have been continued for some years to come if it had not been for the serious shortage which affects this portion of the province and which will be overcome by the completion of the Chippewa Creek development. Besides the power supplied to metal industries as shown on Fig. V. it must be remembered that many other industries are supplied by the Hamilton Hydro ystem. All the street lighting is done by them as well as about fifteen thousand homes, which are lighted and generally served by "Hydro."

The Hydro Electric rates are arranged in a very attractive way for the ordinary power consumer and specially so for one who carries a more or less continuous load. As a sample of this we would quote the account of one company having a demand of about 800 K.W., and a connected load of 1,800 K.W. The K.W.H. consumption for 1917 was 3,343,800, and the year's account amounted to $12,639.29, which is an average price of 0.38 cents per K.W.H., though occasionally, if the load factor happened to be specially good, the monthly average rate came to very little over a quarter of a cent per K.W.H.

It is interesting to contemplate the condition that would have existed in this part of Ontario if it had not ben for the Hydro ystem. Fuel, gas, and power shortage would have been tremendously increased, and with it the financial loss and physical suffering, to say nothing of reduced production of war material.

Perhaps one of the best drawing cards for many years to the iron and steel industry to this city was the Hamilton Blast Furnace Co. Later this was amalgamated with the Ontario Rolling Mills and became The Hamilton Iron and Steel Company, Ltd. The large steel merger some seven or eight years ago changed this to the Steel Company of Canada, Limited. The cheap freight rate on pig iron and steel, with the greater ease in chasing it up, has undoubtedly been quite an attraction to many industries to locate here.

Another item to consider has been the large and suitable manufacturing sites available in the East End of the city at very reasonable rates, not only with easy switching connection to both C. P. R. and G. T. Railways, but many of them on the water front giving private wharves for lake shipping.

The managers of a number of firms interested in this question have given as their opinion that the pleasant and comparatively cheap living conditions go a long way towards obtaining suitable labor at a reasonable rate. Fruit and vegetable farms all around the city, natural gas and electric power for cooking and lighting, at minimum rates, large vacant properties in the East End, well tapped by car lines and suited for dwelling houses, all tend to bring about these conditions.

From the above notes, it will, I think, be agreed that rather than one outstanding reason, it is a happy combination of natural situation, resources, and circumstances that gives Hamilton its prime importance in this most essential industry.

We have not touched on war work in this article as it is more of an exceptional industry than one by which the normal activities of a community can be judged. It is needless to say that in the line of iron and steel, Hamilton has quite done her share in this unique activity.

# Electric Steel Melting Furnaces

Our frontispiece gives a good view of one of the three-phase Heroult furnaces in use for melting steel scrap at the plant of the Electric Steel and Metals Company at Welland. Similar furnaces, but of a rather greater power and capacity, are installed in the plant of the British Forging Company at Toronto. In this, which may be regarded as the standard steel melting furnace, three carbon electrodes are used, and they all enter through holes in the arched roof of the furnace. Electrical connections are made only to these three electrodes, and no connection is made to the bottom of the furnace, which has no electrical function, but serves merely to support the molten steel. The bottom is usually made of burnt magnesite, and can be repaired without difficulty when it becomes worn.

In another type of furnace the electric current enters by one or more carbon electrodes, but leaves by means of steel rods embedded in the bottom of the furnace. The earliest of these, the Girod furnace is not well known in this country, but a more recent modification, the Snyder furnace, is largely used. This furnace has one carbon electrode entering vertically through the roof of the furnace, and an electric arc is formed between the lower end of this electrode and the pile of steel scrap in the furnace. A steel rod, passing through the bottom of the furnace, makes contact between the scrap and a water cooled terminal underneath the furnace, which is connected to the transformer.

In a third type of furnace a bottom terminal is used, but there is no steel rod leading through the furnace hearth. In such furnaces the electric current must flow through the refractory lining of the hearth, which is usually burnt magnesite. This material is a very poor electrical conductor when cold, so that it would be impossible to heat a furnace by the amount of current that would pass through any thickness of it. At a high temperature, however, the magnesite hearth becomes a fair conductor and the current can then enter by a carbon electrode, and leave through the bottom terminal. When the furnace is cold the heating current must be supplied in such a way as to be independent of the bottom terminal. The earliest of these furnaces, the Electro-Metals Furnace, has two movable carbon electrodes entering through the roof, and a carbon block embedded in the bottom of the furnace, connected to the bottom terminal, and covered and protected from the molten steel by a layer of the magnesite hearth lining. Two-phase current is employed, the upper electrodes being connected to opposite phases, and the bottom terminal forming a common return for both phases. Starting with a cold furnace there is a voltage between the upper electrodes equal to 1.4 times the voltage of either transformer, and the furnace operates as a single-phase Heroult furnace. When the hearth has become thoroughly heated, and therefore electrically conducting, the current, entering by either electrode, can pass through the hearth to the bottom terminal, and the two phases operate independently. A new electric steel furnace of this type, the Booth-Hall furnace, is described elsewhere in this issue. In this furnace, which is usually operated by two-phase current, the bottom contact consists of an iron grid embedded in the hearth, but covered by the lining material. The special feature of this furnace is an auxiliary electrode entering through the roof and making contact with the pile of scrap to be melted. With this addition the two phases can operate independently from the start, which makes the running of the furnace simple and more regular. When the furnace has become fully heated, contact is effected through the grids in the hearth, and the auxiliary electrode is withdrawn.

# A New Electric Furnace

(Metallurgical and Chemical Engineering, Feb. 15, 1918.)

The Booth-Hall electric steel furnace shown in the accompanying illustrations was recently placed in operation in the plant of the Midland Electric Steel Company, Terre Haute, Ind. The furnace has a holding capacity of three to five net tons, and is supplied by two single-phase transformers of 600 kva. capacity each. The transformers are Scott-connected to the 13-200-volt, 60-cycle, three-phase power line, and deliver current to the furnace at 125 volts secondary. The Scott connection gives a load well balanced over the three-phase primary circuit, as is evidenced by the meter readings. A special switch is provided for cutting the voltage in half when refining or holding heats. The electrodes are automatically regulated and, by proper manipulation of the electrode manipulators and the voltage reduction switch it is possible to put any fraction of full power into the furnace. The furnace operates at about 90 per cent. power factor, giving a power input at full load of from 1000 to 1100 kw.

This furnace is built for use on either single, two- or three-phase power lines, and the furnace itself is built to operate either single, two or three-phase. The single-phase furnace employs an auxiliary electrode, a main electrode, a conducting hearth and a cast-steel grid buried under the hearth. The two-phase furnace employs two main electrodes and two grids, whereas the three-phase furnace employs three main electrodes but only one grid. It is anticipated that the furnace for single-phase operation will be built only in the smaller sizes, as a single-phase load of any considerable size is not acceptable to power-companies. Three-phase operation will be employed only in the largest capacities where the increased number of electrodes will tend to facilitate melting down and refining. The two-phase furnace will be suitable under

most conditions, and it is with such a furnace that this article deals.

Scrap steel, ranging from machine shop turnings to heavy melting steel, is charged into the furnace. When the furnace is charged the auxiliary electrode and the two main electrodes are let down until they rest upon the scrap. A pawl upon the auxiliary electrode holder is released so that the electrode rests of its own weight upon the scrap and the main electrodes are drawn up, creating an arc under each, the arc being governed by the automatic electrode regulators, assuring a uniform power input into the furnace and a nicely balanced load in the power lines. This results in heat being generated by the two arcs from the main electrodes to the scrap, while the auxiliary electrode, under which no arc is formed, acts as the common return. By reason of the electrode resting of its own weight upon the scrap, no arc can form under the auxiliary.

When a pool has been formed on the hearth sufficient to make it conductive of electricity, the current begins to flow through the hearth and out through two sets of steel grids embedded beneath the hearth. The fact that this is taking place is immediately recorded by the ammeters, and the auxiliary electrode is then drawn out of contact with the scrap and forms its own seal of the electrode opening in the roof. The furnace then continues to operate as a two-phase furnace, with two independent circuits, the current from one side of each transformer making a complete circuit through one electrode, across the arc, through the bath and the hearth to the opposing grid, and so back to the other side of the transformer.

It is to be noted that the auxiliary electrode is withdrawn before the scrap underneath melts and consequently no carbon is absorbed by the liquid steel from this source.

The advantages claimed for this principle of operation are:

(1) The use of the auxiliary electrode renders the starting of every heat positive and does away with trouble in making contact.

(2) The use of the conducting hearth gives uniform heating of the entire bath, prevents sculls and makes speedier and more thorough distribution of the heavier alloys, such as chrome, tungsten, vanadium, manganese and nickel, which sink to the bottom of the bath.

(3) The use of two independent circuits, criss-crossing in the bath, combined with bottom heating, gives a maximum circulation of the bath.

(4) The use of an auxiliary electrode in combination with a conducting hearth enables the use of a minimum number of electrodes for multi-phase service, since the auxiliary electrode is used only at the very beginning of the heat when conditions are least severe. This results in lower electrode consumption and reduction in heat losses.

(5 The hearth is solid, similar to the open hearth, with no openings or bottom contact to weaken the lining, and is sintered in place, layer by layer, forming a monolithic mass. There is no water-cooling of hearth or grids, and the operation of the furnace has shown that none is necessary.

On an absolutely cold bottom it is necessary to employ the auxiliary electrode for about 45 min. before the hearth becomes conductive of electricity. On a furnace that has been shut down over night it requires from 20 to 30 min., and on a hot furnace no more than 10 min., and frequently not at all.

The Booth-Hall furnace is spherical in shape, with a saucer-like bottom. The shell is made of ½-in. riveted steel plate. The main electrodes are placed on opposite sides of the furnace and the auxiliary electrode directly alongside one of the main electrodes and toward the front of the furnace.

The furnace may be lined either basic or acid, the unit at Terre Haute being lined basic. The hearth is 24 in. thick, and the grids are 18 in. below the top of the hearth. The furnace hearth is composed chiefly of either magnesite or dolomite and is solidly sintered in, layer on layer. From the hearth up the walls are made of brick, the first three rows which reach above the slag line being made of magnesite brick and the rest of silica brick. Silica brick are employed for the roof.

The furnace door is of improved design, consisting of a door with open back to which is attached two

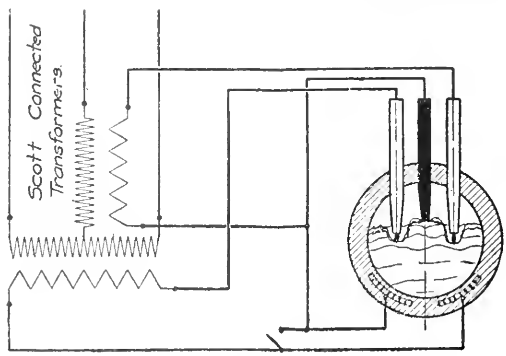



Fig. 1.—Diagrammatic Lay-out of Two-phase Furnace.

yokes, each counter-weighted. The yokes extend part way from the door toward the sides of the furnace, and by reason of the counter-weights the door can be raised with one hand by the furnace operator. The door is built in with brick, the open back allowing radiation of the heat and preserving the brick. The door pivots on the yokes as it is raised and lowered, keeping the hot inner side always to the furnace wall. The door is oval in shape so that there is no tendency to breast up the opening, as is done where round doors are employed, and there is, therefore, maximum charging space. It is possible to raise the door as far as required so that for looking into the furnace for rabbling or for taking out test ladles, the entire opening does not have to be employed. The door comes down flush against the door frame, preventing heat losses from the furnace, and also the seeping of air into the furnace to disturb the furnace conditions. The door frame is made in two sections, one of which extends across the top and can be readily replaced when burnt out.

By placing the door in the rear of the furnace charging and slagging operations are simplified. By tilting the furnace forward it is possible to charge the furnace quickly by the use of a hopper arrangement

similar to that used for charging concrete mixers. By tilting the furnace backward it is possible to bring the slag flush with the door sill, either for rabbling or for pouring it off into slag pots. It is also practical to pour fluid slags over the charging spout.

The furnace is tilted by a very simple arrangement of rockers, structural steel struts and reducing gears. The rockers are placed under the furnace in such a way that there is no possibility of material falling on the guides and interfering with the tilt. The furnace tilts backward as well as forward, so that it is possible to bring the slag line flush with the door when slagging from the furnace, making slagging a speedier operation and easier on the furnace men.

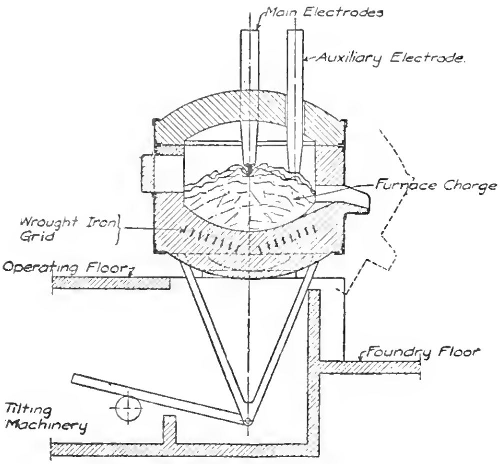



Fig. 2.—Electrical Connections for Two-phase Furnace.

The electrode clamps are of an improved construction which allows of clamping or releasing the electrode by turning a lever at the edge of the furnace and does away with necessity of the operator climbing on the furnace roof. Each segment of the electrode clamp is water-cooled. The electrode holders are of rugged construction, each being capable of holding 10 tons at the end. Magnetic circuits are broken up by a special construction.

It will be noted in the accompanying illustrations that no electrode water cooling collars are shown in the roof, due to the fact that a temporary arrangement of the three electrodes is used, and it has been found difficult to make a practical collar under the circumstances. The design of the furnace calls for a special type of electrode collar, which fits around each electrode, extending well down into the roof brick, providing further protection for both the electrodes and the roof arch at this point. Differing from other types of electric furnaces, the Booth-Hall has provided not only water-cooling collars around the electrodes, but water-cooling in the electrode clamps themselves.

The Booth-Hall electric steel furnace was originated by William K. Booth, and its mechanical design carried out by Julius R. Hall. The furnace is manufactured by the Booth-Hall Company, Chicago, Ill.

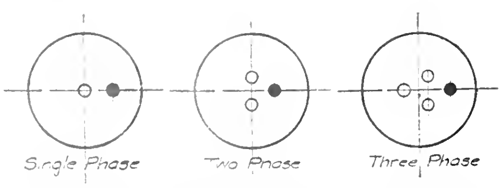



Fig. .—Relative Location of Main and Auxiliary Electrodes in Single, Two and Three-phase Furnaces.

## ELECTRIC STEEL MAKING AT WELLAND.

The Electric Steel & Metals Company, Limited, of Welland, the first company in Canada to install an electric furnace for the manufacture of steel, commenced operations on a modern foundry building for the manufacture of high grade steel castings in November, 1913.

The company owns over twelve acres of ground adjoining the Welland Canal. The main foundry building is 500 ft. long x 80 ft. span, having two 10-ton electric cranes for handling the product. Various smaller sized buildings are used for pattern shops, cleaning castings, stores, etc. Also a machine shop 300 ft. long by 50 ft. span, where a general engineering business is carried on.

In the foundry are two 6-ton Heroult electric furnaces, which are shown in the frontispiece. The power is received direct from Niagara Falls, at 46,000 volts, 25 cycle, 3 phase. Crocker Wheeler 1200 KVA. transformers are used to supply the current to the furnaces, at 110 volts. Carbon electrodes of 17" diameter are automatically regulated by Thury regulators.

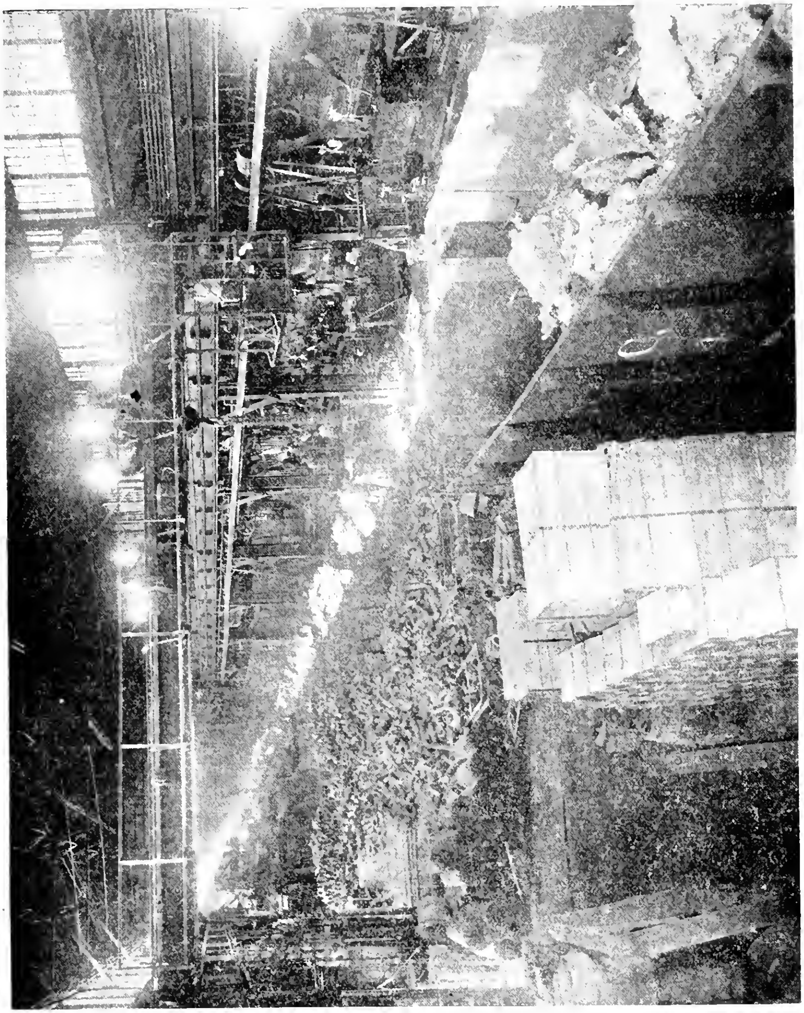
Sixty-five to seventy tons of steel are tapped daily from the furnaces, which have a basic lining; steel scrap being used entirely in the manufacture. It is generally recognized by steel manufacturers that basic electric steel castings are superior to all others, due to the fact that the steel can be refined for low phosphorus and sulphur contents.

## ELECTRIC MELTING OF STEEL.

In view of the large development of electric furnaces in Canada for melting scrap and producing steel billets for shell making, it is desirable to know whether these new appliances will be able under normal conditions to compete with the open-hearth and the converter in the production of steel castings.

A paper by C. R. Messinger, Iron Age, February 14th, 1918, p. 446, answers this question with respect to the converter, and indicates that the acid single phase-furnace—such as the Snyder furnace now in operation in Montreal—has a slight advantage in normal times as compared with the cupola and converter for the production of steel castings.

The article is too long for effective summary, but we expect to deal with this and similar subjects more fully at a later date. For the present, however, it may be noted that this comparison is between two appliances each of which is adapted merely for melting pure non-phosphoric stock, steel scrap or pig iron respectively, for the production of steel castings. The paper does not deal with the treatment of high phosphoric stock, nor with the production of tonnage steel for rolling.



FOUNDRY OF ELECTRIC STEEL AND METALS CO., WELLAND.

# The Fuel and Power Problem of Canada

**A Summary of the Two Day Conference of Engineers in Toronto.**

Believing that a discussion of the all important fuel power problem by its members would result in the development of ideas beneficial to the whole Dominion, the Canadian Society of Civil Engineers planned a two day conference which has just closed in Toronto where a number of valuable papers were delivered by experts on the subject, leading to a discussion of the various phases involved, with suggestions as to a policy to be adopted.

Mr. H. H. Vaughan, President of the Canadian Society of Civil Engineers, who presided at the meetings, called attention to the fact that the papers to be presented were of two characters. One of these dealt with the immediate relief of the present situation and the other evolving a policy of a future rational use of fuels and the development of power.

It was pointed out at these meetings that the fuel and water power resources of Canada were of enormous extent, and in view of this it was incumbent upon the Canadian people to develop these resources in a scientific manner and make them available for use as soon as possible. In the meantime as far as Canada is concerned, and particularly the middle portion of the country, we were still dependent upon the good will of the United States for fuel supplies.

Of these fuels which offer relief from the present situation wood stands out as the one source of supply from which immediate help may be expected, and consequently as far as Ontario is concerned it is imperative that aggressive action be taken by the various municipalities to provide a supply of wood for domestic purposes for the coming winter.

It was shown that the art of manufacturing, and using peat fuel has been well advanced in other countries so that there is little doubt that air dried machine peat will in the near future be used to some extent to take the place of coal. Peat is particularly well suited for use in gas producers, more especially those of the by-product type. When burnt under boilers the steam raising value of peat is about one-half that of good coal.

A further relief in the fuel situation is promised by the industrial evolution of the carbonization of coking coals. In the past this led to the employment of high temperatures with the production of strong metallurgical coke and high yields of city gas, but a commendable reaction has set in towards low temperature and high tar yields, as tar oils are increasingly needed for motor fuels. A systematic investigation of lignites now in progress in the fuel testing laboratories at Ottawa shows that a valuable fuel of high heating value can be made by suitably controlled carbonization followed by briquetting. Carbonized peat or peat coke is a high grade fuel which need not be briquetted.

A rational development of Canada's fuel resources would indicate that, on account of its importance and exhaustible nature, coal should be won and used for the purpose for which it is best suited. Suggestions as to this development were: (1) Substitution of coke for anthracite; (2) The introduction of by-product coke ovens, and the transformation of gas plants to include a more thorough by-product recovery; (3) Carbonization and briquetting of low grade fuels; (4) The use of pulverized coal as a locomotive fuel; (5) The elimination of waste in mining; (6) Greater use of western coals to replace imported coal in the area west of Port Arthur, thus avoiding the use of fuel requiring a long haul wherever it is possible to procure a suitable substitute requiring only a short haul; (7) By the earliest exploitation of our own resources to aim at limiting the necessity for importing fuel from other countries.

While oil is an ideal fuel for all purposes it will never be a competitor of coal to any extent in this country unless the production of oil is materially increased, but it will always be a splendid supplementary fuel.

### Fuel Conservation.

The possibilities of relieving the fuel consumption in Canadian industries by the increased use of Hydro electric energy lie: First, in limiting in existing plants the use of coal to heating purposes wherever hydro electric power is available, such limitation having as its object the restriction of the use of unreplacable material by power derived from natural sources which do not suffer depletion by use. Second, the establishment of a national policy which will ensure that in the future factories shall be located at points where their demands for raw material and power may be met by the most economical use of such materials and facilities as are indispensable for their operation.

Central heating as a means of conserving fuel was suggested, coal being burnt at a central point and the heat being transmitted to those who would otherwise burn coal. This heat can be piped as high or low pressure steam or hot water. Such a system if applied to the business section of Toronto would save $100,000 per year in coal alone. A prediction was made that within ten years powdered coal would be transported in pipes from the mine to the user replacing the carriage of bituminous coal in cars.

Railway electrification offers great theoretical promise of conservation both by saving coal and by increasing the capacity of tracks and terminals of congested railway districts. By the use of electrical energy for railway operation, if obtained from water power, all the coal now consumed by steam locomotives would be saved. An electric locomotive does three and a half times as much work in ton miles as a steam locomotive. This question is, however, a highly specialized one, involving economic, financial and engineering considerations, while the high cost of apparatus due to labor and other conditions prohibits the carrying out of railway electrification on a wholesale scale.

The universal heating of buildings by electricity was shown to be economically out of the question to-day and very improbable in the future. Two million horsepower would be required to heat electrically Toronto's buildings which house a population of five hundred

thousand people. Heat from bituminous coal is normally one-tenth the cost of heat from electricity. At existing prices one cent will purchase the following units of heat applied to buildings:—anthracite coal 14,300 units, bituminous coal 24,000 units, oil 7,750 units, electricity 4,200 units. Electric heaters now operate at one hundred per cent. efficiency and the marvellous inventions frequently announced cannot improve them. The general electric heating of buildings should not be allowed, as at the present time the power consumed should be used for munitions and for industrial purposes.

Water power development.—Canada is recognized as one of the great water power countries in the world. No country enjoys to a greater degree the benefits of cheap dependable hydro power and no country has had that benefit more universally applied for municipal, industrial and domestic use.

Water power must take a very prominent part if the best use of the varied fuel-power resources of Canada is to be achieved. There must be evolved a national master fuel-power policy which will realize the best possible co-ordinated and concentrated development for the use of all the fuel-power resources of the Dominion.

Cheap power promises to be one of the country's greatest assets in the post bellum industrial rivalry of nations for world trade. Our great fuel reserves supported by our water-power resources represent a sure source of cheap power and should guarantee Canada her share of world trade if these resources are availed of to their maximum possible advantage.

---

# Grants for Industrial Research

The Honorary Advisory Council for Scientific and Industrial Research, is prepared to give grants of money for assisting researches of industrial importance. These grants are designed chiefly to assist workers in the solution of some problem which is of importance to the national industries of Canada. These awards will be by no means confined to University men, but are open to all who are engaged in research under conditions which are stated in the regulations.

It will be noted that the grants are not designed to support the grantee while carrying out the investigation, but are intended to provide him with assistance, special apparatus and materials to enable him to efficiently attack the problem which he has in hand. Application for assistance in carrying out any definite line of research can be made to Dr. R. F. Ruttan, McGill University, Montreal.

**Regulations Governing the Award of Grants for Research.**

1.—The recommending of the giving or refusing of grants by the Advisory Council shall be in the hands of a Committee of three members of the Council to be known as the Committee on Assisted Researches. This Committee may utilize the advice and assistance of any persons inside or outside the Council who, in their judgment, may be of value in any application under consideration.

2.—The applicant must give a brief statement of the proposed investigation, its scope, time required, results hoped for, total cost, grant asked, specific purpose to which grant applied for is to be put, evidence of ability to carry on the investigation, concise statement of adequacy of general equipment of laboratory where investigation is to be carried on. If the applicant has asked for or is receiving a grant from any other body, he must state this fact in his application.

3.—Grants will, as a general rule, only be made to persons who are conducting investigations in established laboratories which possess the fundamental apparatus and facilities necessary for research of the nature proposed, and where the ordinary overhead charges are already provided for, and will not be made for the purchase of standard apparatus which a well-equipped laboratory should possess.

4.—Grants made are to be for requirements for one year only, but further grants may be made annually.

5.—Grants will be made only to persons who can show capacity for independent research, and who have a reputation for trustworthiness and responsibility.

6.—Grants are to be made only for the actual expenses of investigation, but may be used in whole or in part for the payment of assistants, and are not intended to support the grantee while carrying out the investigation.

7.—When a grant has been made for a specific purpose, it must be used for that purpose only. If the grantee desires to change in any manner the subject of his investigation he must make application to have the grant made available for the altered investigation.

8.—All apparatus and materials purchased with grants are to be regarded as the property of the Advisory Council, and when the investigation is concluded are to be subject to the disposition of the Council.

9.—A report of progress is to be made annually by the grantee, or whenever called for, and, in every case, on the completion or conclusion of the investigation.

10.—The grantee shall render annually, or whenever called upon, an itemized account of his expenditure, with vouchers. Such account shall also be made on the completion or conclusion of the investigation, and the balance of the grant required shall be paid over to the Advisory Council.

11.—The grantee shall present a complete copy of the results of his investigation, before its publication, to the Advisory Council, who shall have the right of publishing it under their own auspices. When the grantee publishes his research, he shall make due acknowledgment of the assistance received from the Council.

12.—The Council will give careful consideration to every application, but will not assign reasons for refusing to make grants applied for.

Dr. Alfred Stansfield has been granted financial assistance for carrying out a series of experiments at McGill University on the treatment of iron ores. The work will be of a chemical nature and an assistant will be needed who can make chemical analyses and carry out the experiments. Applications for this position should be made to Dr. Stansfield.

# Effect of Copper in Medium-carbon Steel*

## High Copper Content as Compared With Low Renders the Steel Superior in Strength, Hardness and Shock Resistance

(Iron Age, Feb. 14, 1918, p. 452.)

Before modern testing methods had been developed, blacksmiths noted red shortness in iron, the cause for which was ascribed to the presence of copper. Numerous papers have been published on the corrosion of steels containing various amounts of copper and a few writers have discussed the effect of copper on the mechanical properties of steel.

The purpose of this investigation was to obtain additional data on the mechanical properties of medium-carbon steel containing small quantities of copper.

Among those who have published results of mechanical tests on copper steels are E. J. Ball who states that copper increases the tensile strength and hardness but lowers the elongation. J. E. Stead states that copper steels closely resemble nickel steels containing equivalent percentages of nickel as regards tensile strength, resistance to shock, corrosion and hardness. F. H. Wigham found that copper in small amounts had no injurious effects on steel. P. Breuil found that with 1 per cent. carbon, copper lessened the brittleness of steel and in low-carbon steel it increased the tensile strength and lowered the ductility slightly. H. H. Campbell states that copper up to 0.25 per cent. slightly raises the elastic limit, elongation and reduction of area.

It will be noted that all the above writers agree that copper increases the tensile strength, but they disagree in regard to the ductility. There is little to be found on resistance to shock.

### Materials Used in This Investigation.

The steels used were obtained through Frank D. Carney of the Pennsylvania Steel Co. They were furnished in the form of forged bars about 1 in. sq. in cross-section and of varying lengths. There were three bars of one composition marked No. 41, 42, and 43 and four bars of another composition marked Nos. 51, 52, 53 and 54. The chemical analyses furnished with the stel are given in Table 1.

**Table 1.—Composition of Steels Used.**

| | Nos. 41, 42, 43 Per cent. | Nos. 51, 52, 53, 54 Per cent |
|---|---|---|
| Carbon | 0.380 | 0.365 |
| Phosphorus | 0.012 | 0.053 |
| Manganese | 0.570 | 0.590 |
| Sulphur | 0.030 | 0.048 |
| Copper | 0.860 | 0.030 |

It will be noted that the analyses vary only slightly except in phosphorus and copper and it is probable that the effect of phosphorus will be neutralized by the slight difference in carbon. Although 0.86 copper is not in general considered high, for the purpose of dessignating the steels in this paper, the first will be called high-copper and the second low-copper.

### Preparation of Specimens.

The bars were first cut to $7\frac{1}{2}$-in. lengths. The cutting was done with an ordinary reciprocating mechanical saw. Three of the bars gave five specimens each, while the fourth bar, which was somewhat longer, yielded six specimens. This made a total of twenty-one $7\frac{1}{2}$-in. specimens of low-copper steel. Each of the other bars yielded seven specimens, making a total of twenty-one $7\frac{1}{2}$-in. high-copper specimens. The bars were now square, but as this form was not the most favorable for heat treatment, it was decided to turn them down round, on a lathe, in order to obtain the most uniform heating in the furnace. As the threads for the tensile specimens would eventually have to be cut on a $\frac{3}{4}$-in. round bar, it was decided to turn the 42 specimens down to this size prior to treatment. The steel as forged was fairly soft and turned very easily on the lathe. There was no noticeable difference in the speed of cutting, between the high- and low-copper steels.

### The Heat Treatment.

Three specimens of high-copper and three specimens of low-coper steel were taken for each test and in order to eliminate possible differences in the bars no two specimens in a set were taken from the same bar except in one or two instances. There were seven different heat treatments, and in order to identify the specimens the numbers 1 to 7 were prefixed before the original number of the bars. Table 2 gives the numbers as finally stamped on the specimens.

**Table 2.—Numbers Used in the Bars.**

| Section | High Cu | Low Cu |
|---|---|---|
| (1) | 141,142,143 | 151,152,153 |
| (2) | 241,242,243 | 252,253,254 |
| (3) | 341,342,343 | 351,352,353 |
| (4) | 441,442,443 | 452,453,454 |
| (5) | 541,542,543 | 552,553,554 |
| (6) | 641,642,643 | 651,653,654 |
| (7) | 741,742,743 | 751,752,754 |

The six bars of section (1) were reserved for tests without heat treatment. The remainder were treated as follows:

Th bars under section (2) were heated to 765 deg. C., the switch was pulled, and the final temperature rise registered due to residual heat was 865 deg. C. The bars were allowed to cool in the furnace over night, and removed next morning.

The bars under section (3) were heated to 765 deg. C., the switch was pulled, and the final temperature attained due to residual heat was 860 deg. C. They were then removed and set inclined against a brick on the cement floor to cool in air.

The bars under section (4) were heated to 765 deg.

*From a paper presented at the New York meeting, February 18 to 22, of the American Institute of Mining Engineers. Mr. Hayward is assistant professor of mining engineering, Massachusetts Institute of Technology, and Mr. Johnston is a graduate student of the same institute.

C., the switch was pulled, and the final temperature attained due to residual heat was 845 deg. C. They were removed from the furnace and dropped into buckets of cold water.

The bars under section (5) were heated to 765 deg. C., the switch was pulled, and the final temperature attained was 865 deg. C. They were removed and quenched in water. Then they were replaced and drawn at 360 deg. C., again removed and quenched in water.

The bars under section (6) were heated to 765 deg. C., the switch was pulled, and the final temperature attained was 860 deg. C. They were removed and quenched in water; then replaced and drawn at 455 deg. C., and finally removed and quenched in water.

The bars under section (7) were heated to 800 deg. C., by mistake, the switch pulled, and the final temperature attained was 900 deg. C. They were removed, quenched, and then drawn at 580 deg. C., and quenched in water.

### Preparation of Test Specimens.

After heat treatment there were 42 bars $\frac{3}{4}$ in. in diameter, and $7\frac{1}{2}$ in. long. Thirty-six of these were sawed up into three pieces 4 in., $2\frac{1}{2}$ in., and 1 in. long. The six bars under section (4) (quenched at 845 deg.), were found to be too hard to saw, and in order to cut them up a thin alundum wheel had to be used. As the wheel was in poor condition, the process took about 4 hr. per bar, so only one high- and one low-copper specimen from this section were cut for tests.

The 1-in. lengths were set aside to be polished on the ends for microscopic work, scleroscope tests, and Brinell hardness numbers.

The 4-in. lengths were turned into standard test specimens 0.505 in. diameter and 2-in. gage length with threaded ends. The bars to be tested as quenched were too hard to turn on a lathe. A 7-in. length was therefore used and the ends annealed in a blacksmith's forge to allow the cutting of the threads. During the heating, the centre was kept cool with water. A 2-in. gage length was then ground at the centre of the bar.

The $2\frac{1}{2}$-in. lengths were ground down into small rectangular bars 0.395 in. square, and 2 in. long, with a slot cut half way through in the middle of the bar. The slot cutter gave a slot 1 mm. wide.

In the tensile tests readings were taken of its yield point, ultimate strength, reduced diameter and elongation in 2 in. The yield point was determined by watching for the drop of the beam and in a few cases by measuring with calipers the change in elongation under equal increases of load. The average results are given in Table 3.

**Table 3.—Average Results of Tests on the Heat Treated Bars.**

| Treatment. | Yield Point, Lb. per Sq. In. High Cu | Yield Point, Lb. per Sq. In. Low Cu. | Ultimate Strength, Lb per Sq. In. High Cu | Ultimate Strength, Lb per Sq. In. Low Cu. |
|---|---|---|---|---|
| Cooled in furnace . . | 52,900 | 45,800 | 86,530 | 78,130 |
| Cooled in air. . . . . . | 64,300 | 53,000 | 90,300 | 84,700 |
| Bars as forged . . . . . | 60,900 | 46,600 | 92,600 | 83,200 |
| Drawn at 580 deg. C. | 110,600 | 80,000 | 123,700 | 109,600 |
| Drawn at 455 deg. C. . . | 136,900 | 100,000 | 151,500 | 129,300 |
| Drawn at 366 deg. C. . . . | 130,000 | 100,000 | 190,800 | 136,300 |
| Quenched at 825 deg. C. | ? | 110,000 | (207,000)* | 135,900 |
| | **Per Cent Reduction.** | | **Per Cent Elongation.** | |
| Cooled in furnace . . . . . . | 49.0 | 46.2 | 26.0 | 26.7 |
| Cooled in air. . . . . . . . . . | 52.7 | 52.7 | 27.3 | 27.3 |
| Bars as forged . . . . . . . . . | 52.7 | 50.9 | 24.8 | 25.8 |
| Drawn at 580 deg. C. . . . . | 56.3 | 54.6 | 32.2 | 32.7 |
| Drawn at 455 deg. C. . . . . | 50.0 | 49.0 | 27.8 | 18.0 |
| Drawn at 360 deg. C. . . . . | 39.1 | 40.2 | 9.2 | 12.8 |
| Quenched at 825 deg. C. . | . . . . | 20.5 | . . . . | 6.5 |

* Broke in threads because of annealing ends for threading.

(Detailed shock and hardness are given in the original paper.)

### Microscopic Examination.

The one fact revealed by the microscopic study was that for the same treatment the high-copper steel was finer grained than the low-copper. The quenched and drawn specimens of high-copper steel were also slightly more martensitic.

### Discussions of Results and Conclusions.

The results need little interpretation. The table of tensile strengths shows a striking superiority of the high-copper steel. The yield point and ultimate strength are in every case higher while the ductility is practically the same, although here too the average figures for reduction of area are with one exception slightly higher for the high-copper than for the low. This, however, is offset by slightly higher values for elongation in a majority of the tests in favor of the low-copper.

The hardness tests by both methods show the high-copper steel in all tests to be harder than the low-copper.

The Charpy shock tests show the high-copper steel in all cases to be superior to the low-copper.

In general, the results confirm the work of Ball, Stead, Breuil, and Campbell as regards the effect of copper on hardness and tensile strength. They confirm the work of Breuil as regards brittleness and the work of Campbell as regards reduction of area. It is also true, that as Stead has stated, the behavior of the copper steel resembled that of nickel steel.

# Nickel-copper Steel

By R. W. LEONARD, M. Can. Soc. C. E.

(Presented to the Canadian Society of Civil Engineers.)

In the early eighties, during the construction of the Canadian Pacific Railway through what is now known as the Sudbury District, some copper ores were discovered, and subsequently a Company was formed to develop the ore bodies. This company—the Canadian Copper Company—sent its ore or matte to the Orford Copper Company's refinery at Constable Hook, N.Y., for treatment, which plant was established for the purpose of treating the copper ores mined at Orford Mountain, P.Q.

When it was realized that these copper ores contained substantial quantities of nickel—for which metal there was very little demand at that time except for the purpose of making German Silver and for nickel plating, the Canadian Copper Company and the Orford Copper Company were merged into the International Nickel Company. This company developed very large proper-

ties at Sudbury and greatly stimulated the demand for nickel, especially for the purpose of alloying with steel to be used for the many purposes so well known to all engineers of the present day.

During the past two years the International Nickel Company has been constructing a refinery at Port Colborne, Ont., for the purpose of completing the process of separation of the nickel from the copper and of refining these products in Canada for the Canadian and foreign trade.

The Mond Nickel Company, of England, also acquired properties in the Sudbury District, and ships its partially manufactured product to England in the form of matte. Latterly the British-America Nickel Corporation has acquired large mineral claims, which it is developing, and is erecting in the Sudbury District metallurgical works to treat its ores.

Although the different companies are pursuing somewhat different processes, in general the operation consists in mining and sorting the ore, then roasting it (generally in open heaps) to largely eliminate the sulphur, and thereafter smelting in the ordinary type of copper-smelting furnaces to a matte, consisting of sulphide of iron, nickel and copper, which matte is further bessemerized for the purpose of eliminating as much of the iron as possible and producing a matte much richer in nickel and copper content, and containing therein some small proportion of the precious metals.

Up to the present time these mattes have been exported either to England or to the United States for refining or separation of the nickel from the copper, and in one or two cases for the recovery of the accompanying precious metals.

The above-outlined process results in the waste of all the sulphur content of the ore, amounting to many hundreds of tons of elemental sulphur per day, to the seriour damage of all plant life in the immediate neighborhood. It also results in the waste of some thousands of tons per day of iron in the slags, which until recently was considered a necessary waste preparatory to separating the nickel from the copper.

The Sudbury nickel deposits, as developed by the mining companies and as worked out by geologists, consist of an oval saucer-shaped basin about 36 miles in length by 18 miles in width, around the South rim of which are located most of the properties of the Canadian Copper Company and the Mond Nickel Company, and around the northerly and easterly rim of which are principally located the properties of the British-America Nickel Corporation. The towns of Sudbury and Copper Cliff are on the south rim. The Canadian Northern Ontario Railway passes in a northerly direction through the eastern portion of the basin, and the Canadian Pacific Railway passes almost through the centre in a north-westerly direction.

An excellent geological map of the deposits accompanies the Monograph on the Sudbury nickel region, by Dr. A. P. Coleman, 1913. This basin is generally conceded to be one of the greatest mineral deposits of the world, containing nickel-copper pyrrhotite of unequalled quantity and richness, which can be mined and the nickel and copper extracted and refined at a cost defying competition.

It is now the principal source of the world's nickel, and is also the source of a considerable amount of platinum and palladium, which are recovered as by-products.

The magnificent report of the Royal Ontario Nickel Commission, 1917, which bears on the nickel production of the world, is probably one of the most complete and valuable reports on any mineral industry extant.

A number of men have experimented with alloys of nickel, iron and copper, commencing with Alexander Parks in England in 1844, who patented a "useful alloy of nickel, iron and copper." Hybinette and Shuler, of Sudbury, made experiments about 1902 in the manufacture of nickel pig from Sudbury ores, and E. A. Sjostedt carried out some experiments in the direct manufacture of nickel pig and nickel steel at Sault Ste. Marie, Ont., for the Lake Superior Corporation about the same time. In 1905, Dr. E. Haanel, Director of the Mines Branch Geological Survey, Ottawa, made, experimentally, some nickel-copper-iron pig from roasted pyrrhotite in an electric furnace at Sault Ste. Marie, under Canadian Government auspices. W. S. Horrey experimented in the smelting of nickel-copper-iron ores at Sault Ste. Marie in 1898. "Metallurgical and Chemical Engineering" of February, 1913, gives a description of the manufacture of nickel steel from nickel pig in an electric furnace at Trondjen, Norway.

In all these experiments an endeavor was made to select ores in which the copper bore the smallest possible proportion to the nickel content, it being believed or feared that the copper was an injurious constituent, except in the case of Shuler, who claimed that the presence of the copper in certain proportions was not objectionable.

G. H. Clamer, of Philadelphia, has used Monel Metal (a natural alloy of nickel and copper as obtained from the Sudbury ores after elimination of the iron and sulphur) in the manufacture of a nickel-copper steel which is in commercial use and is said to have been successfully employed even in the manufacture of armour piercing shells for the United States Government, and the results are reported to have been very satisfactory. This nickel-copper steel is also being manufactured into commercial sheets.

Mr. George M. Colvocoresses, at one time in the employ of the Orford Copper Company and who has had a valuable experience in the mining and metallurgy of nickel and copper in Canada and New Caledonia, made laboratory experiments in the production of nickel-copper steel direct from the Sudbury ores, and has taken out patents on his process. In these patents he claims the direct smelting of Sudbury nickel-copper ores or the slags wasted in the present process, either by electricity or with fuel, into a nickel-copper (Nicu) steel, claiming that in this direct smelting process the copper up to a certain proportion, may be considered as taking the place of an equal amount of nickel, and that not only is the presence of copper not detrimental, but that, on the contrary, it may be advantageous in that it produces — owing to certain qualities of the copper — a superior product which can be manufactured at much less cost than nickel steel made by the ordinary practice of alloying refined nickel with steel in certain definite proportions.

During the past year Mr. Colvocoresses, with some associates, has experimented in the manufacture of nickel-copper steel direct from the Sudbury ores, for which purpose about 200 tons of ore and 40 tons of slag were obtained from the Sudbury District and experiments were carried on at the plant of the Canada Cement Company, at East Montreal.

This ore was roasted in a hand-rabbled furnace and

smelted to pig in an electric furnace of the Heroult type, and some of it was afterwards refined into steel in the same type of furnace, and the balance in an open-hearth furnace using producer gas.

The blast furnace slag from Sudbury did not require roasting owing to its low sulphur content, but it was smelted to pig in the electric furnace and afterwards refined to steel in the same manner as the ore.

The experiments at Montreal were under the direct supervision of Mr. H. A. Morin, who had previously been associated with Mr. Colvocoresses in the smelting of Sudbury ores, and I think I cannot do better than quote substantially and at some length from Mr. Morin's report on the result of these experiments.

In his report, dated December 7th, 1917, Mr. Morin explains that the experiments consisted in desulphurizing iron-nickel-copper sulphide ores mined in the Sudbury-Ontario District for the purpose of smelting and reducing these ores, with suitable fluxes, and producing an iron-nickel-copper pig of homogenous composition which, preferably in its molten state, could be refined to a nickel-copper steel, with or without foreign ferrous addition, according to the grade of Nien Steel desired.

Another experiment was made in the smelting of blast furnace slag, which slags are produced in large quantities in the smelting of the Sudbury ores (partially roasted) in a blast matting furnace. While these slags will produce a pig low in nickel and copper, it is a simple matter to increase the nickel-copper content by the proper addition of roasted nickel-copper ore.

The following is an average analysis of such ores and slags:

| | Nickel-Copper Ore | Blast Furnace Slag |
|---|---|---|
| | % | % |
| Iron | 40-50 | 40-45 |
| Nickel | 3-4 | 0.35-0.5 |
| Copper | 1-1½ | 0.25-0.35 |
| Sulphur | 25-30 | 1.25-2.5 |
| Silica | 12-20 | 20-30 |
| Alumina | 3-4 | 6-7 |
| Lime | 2-3 | 2-3 |
| Magnesia | 1-2 | 1-2 |

These experiments were carried on in accordance with the description given in the Patent papers issued and granted, both in Canada and the United States, to Mr. G. M. Colvocoresses.

*Ore Supply.*

According to the Royal Ontario Nickel Commission Report, published in April 1917, a total of 75,000,000 tons of ore had been developed by the operating companies up to that time, and the report further states that out of 110 miles of nickel-bearing formation, only about ten miles have been developed, partially, by diamond drill, and that consequently it is fair to assume that this ten miles of partly developed formation is capable of further extending the ore bodies within this area.

The ore secured for these experiments, amounting to about 200 tons, was purchased from the Algoma Steel Corporation and was of rather low grade. Theoretically, it should have produced a 3 to 3½ per cent nickel-copper steel, but in actual operation the nickel-copper pig was considerably diluted, by reason of the fact that the furnaces used had built-up banks and bottoms of iron which had formed during the previous operation of all the furnaces in the production of pig from scrap. The high temperature at which the ore was smelted very quickly dissolved these bottoms and banks, and consequently the desired grade of nickel-copper steel was not realized.

The ore obtained for treatment was mined from one of the properties of the Algoma Steel Corporation about 14 years ago and, having been exposed to the air and weather during all that time, was decomposed and the nickel-copper-sulphur content was considerably leached out. The following is a close approximation of the composition of the ore when it was first mined and as it is to-day:

| | Freshly Mined Ore. | Ore Received. |
|---|---|---|
| | % | % |
| Iron | 45 | 46 |
| Nickel | 2.9 | 1.35 |
| Copper | 0.75 | 0.25 |
| Silica | 17 | 19 |
| Sulphur | 30 | 8 |

*Ore Roasting.*

This step in the process was carried out in a reverberatory furnace constructed to heat steel shells to a forging temperature; and while this furnace made a very complete roast, its design was not suitable for roasting and resulted in high costs for labour and fuel.

The ore, entering the furnace with 8 per cent sulphur, was drawn out after a five-hour roast at a temperature of about 1400 deg. F. with a sulphur content of from 0.3 to 0.6 per cent.

This oxidized ore required no crushing before roasting, the few lumps remaining in the raw state breaking quite easily after being subjected to the furnace heat.

The following is a screen test on the roasted ore:—

| | | | | |
|---|---|---|---|---|
| 5% | through | a | 100-mesh | screen. |
| 10% | " | " | 80-mesh | " |
| 14% | " | " | 60-mesh | " |
| 25% | " | " | 40-mesh | " |
| 16% | " | " | 20-mesh | " |
| 18% | " | " | 10-mesh | " |

Balance in lumps of various sizes.

During the period of September 18th to October 25th, about 200 net tons of this ore were roasted and, due to the necessary excessive handling, a considerable loss of material resulted, probably most of the 100 and 80-mesh fines being carried off as dust, leaving approximately 185 net tons available for smelting purposes.

*Smelting Roasted Ore to Pig.*

Considerable difficulty was encountered in attempting to reduce ore in an electric open-hearth steel furnace which was not in very good condition. Owing to the unusually high silica content of the ore it was necessary to use a high percentage of lime to properly slag off the impurities. The following is an average furnace charge:

| | |
|---|---|
| Roasted Ore | 1400 lbs. |
| Burnt Lime | 525 " |
| Coke Breeze or Coal | 375 " |

Usually from six to eight of such charges were smelted before pouring a heat. During the month's operation 44 heats of Nien pig were poured of an average weight of about 3,200 lbs. and having an average composition as follows:

| | Average analysis of ore charges. | Slag Produced. | Pig Produced. |
|---|---|---|---|
| | % | % | % |
| Iron | 46 | 2.20 | Sulphur.....0.09 |
| Nickel | 1.3 | Trace | Phosphorus.0.07 |
| Copper | 0.28 | Trace | Manganese..0.18 |
| Silica | 19.9 | 25.00 | Silicon......1.75 |
| Alumina | 3.8 | 6.40 | Carbon......3.00 |
| Sulphur | 0.3 to 1.5 | 0.65 | Nickel......2.20 |
| Lime | 2.7 | 45.00 | Copper......0.40 |
| Magnesia | 1.3 | 20.00 | |

*Smelting Copper Cliff Slag to Pig.*

This slag was smelted in the same manner as the roasted ore, having a very similar composition and therefore requiring but a slight variation in the proportion of the fluxes. It is particularly interesting to note that the slags used in this experiment contained 2.2 per cent sul-

phur, and after smelting this slag in an electric furnace the resultant pig contained 0.065 per cent sulphur.

Mr. Morin reports that the conversion of the pig to steel in the open hearth furnace proved entirely satisfactory, the operation being identical with the production of steel from ordinary pig iron. Ten heats were made in all some 27,000 lbs. of high sulphur Nicu steel was equally divided and formed part of heats Nos. 4, 5, 6, and 7. No. 3 heat was too high in carbon and was remelted forming part of heats Nos. 8 and 9. No. 10 heat was made from pig smelted from Copper Cliff slag.

The tables appended hereto give the chemical analysis as well as the result of a few mechanical tests made on some of the heats in their natural state, and after heat treatment.

### *Size of Cast.*

The major portion of the steel produced was cast into moulds $10\frac{3}{4}$ in. square at the bottom and $12\frac{3}{8}$ in. square at the top, each of these ingots weighing about 1,350 lbs. From each heat a few ingots were cast into 6 in. shell moulds weighing about 175 lbs. Altogether there were cast 107 large ingots, total weight 144,450 lbs.; 60 small ingots of 175 lbs.; total weight 10,500 lbs.

While the steel produced during this experiment cannot be compared with nickel steel containing about $3\frac{1}{2}$ per cent nickel, it compares very favorably with steel having a similar nickel content to the combined nickel-copper in this steel, which, it is claimed, verifies previous results obtained from steel of the standard type of $3\frac{1}{2}$ per cent combined nickel-copper, which was shown to possess equal qualities to that of a straight $3\frac{1}{2}$ per cent nickel steel.

### *Possibilities.*

While it would appear that with cheap electric power and a properly designed electric furnace of the shaft type for ore reduction, we can successfully smelt and reduce these nickel-copper ores to a low-sulphur pig, we are also confident that practically the same results can be obtained by an ordinary iron blast-furnace, by first roasting the ore to about 1-$1\frac{1}{2}$ per cent sulphur, and nodulizing in rotary kilns, by which means the sulphur would be reduced to 0.3 per cent.

The Lake Superior Corporation at the present time is roasting a considerable tonnage of their Magpie Mine ore (containing from 5 to 11 per cent sulphur) from the Michipicoten district, in Wedge furnaces down to 0.7 to 1.0 per cent sulphur, which roasted ore is afterwards mixed with an equal amount of lump ore of low sulphur content. This mixture is smelted in a blast furnace and produces a pig iron containing from .2 per cent to .3 per cent sulphur. They have no difficulty in making low sulphur steel by the basic open-hearth process from this pig.

In conclusion, it is claimed that the results obtained are excellent as proven by mechanical tests, and the copper seems to replace some of the nickel in nickel steel without causing red shortness.

Mr. Colvocoresses, from his experiments, has arrived at the conclusion that the best results are obtained when the ratio of copper to nickel is as 1 to 3 or 1 to 4 and that the total copper content should not exceed 1 per cent if the copper is to be considered as replacing an equal percentage of nickel and the steel produced is to be put to the ordinary uses for which nickel steel is employed. The greater part of the nickel steel produced today contains about 3 per cent of nickel, and it has been found that nickel-copper steel containing $2\frac{1}{2}$ of nickel and .75 per cent of copper is similar and equal to a straight 3 per cent nickel steel.

Nickel-copper steel possesses qualities, however, which give it the advantage over straight nickel steel, namely, a greater uniformity in composition and a decreased liability to corrosion owing to the presence of the copper. This latter quality, when fully demonstrated, should give Nicu steel the preference over ordinary nickel steel for ship plates and machinery parts where such are subject to the action of acids, salt water and other corrosive agencies. Experiments made by Clamer to discover the effects of these destructive agencies on nickel copper steel were highly favorable, and it has been known for a long time that a small addition of copper to ordinary steel is used by steel manufacturers in making special kinds of non-corrosive steels for use in locations where there is danger from corrosion.

Of course, it is too soon to say yet how Nicu steel will stand up under the variety of uses to which nickel steel is put, such as in the manufacture of armour plate, steel rails, etc., but the tests and experiments which have already been carried out give every promise of a highly satisfactory product for these purposes, and it is confidently expected that when the many advantages of nickel-copper steel are fully realized and the existing prejudice against the presence of a small percentage of copper in steel has been removed, a large demand will develop for this product.

The question of costs is an important one, and as Nicu steel has not, as yet been manufactured on a commercial scale (with the exception of the small tonnage manufactured in Montreal during the past season where the conditions did not permit of any comparative figures of cost being kept) estimates of cost must be approximate; but Mr. Colvocoresses estimates—and his figures would appear to make due allowance for the several operations from the mining of the ore to the production of the finished steel—that Nicu Steel can be produced from ore at a cost of $35.00 per ton under normal conditions, provided suitable ore containing approximately the desired proportions of nickel and copper can be obtained. Where slag is used as a raw material he places the cost at $30.00 per ton for Nicu Steel produced therefrom. All of which affords a very favorable comparison with the normal selling price of nickel steel at $60.00 per ton—and at $100.00 per ton under the present abnormal conditions.

The writer is indebted to Mr. H. A. Morin, of the Nicu Steel Corporation, for the tables appended hereto, giving the results of chemical analyses and physical tests of Nicu Steel in comparison with Nickel Steel of commercial composition.

*Table 1.—Chemical Analyses of Ten Heats of Nicu Steel Made in Montreal.*

| Heat No | Carbon. | Silicon. % | Sulphur. % | Phos. % | Ni. % | Mn. % | Copper % |
|---|---|---|---|---|---|---|---|
| 1 | .20 | .03 | .03 | .006 | 2.13 | .51 | .40 |
| 2 | .17 | .023 | .046 | .005 | 1.07 | .09 | .20 |
| 3 | .73 | .012 | .037 | .012 | 2.14 | .93 | .33 |
| 4 | .28 | .014 | .038 | .005 | 2.16 | .58 | .41 |
| 5 | .34 | .023 | .029 | .004 | 1.79 | .69 | .35 |
| 6 | .37 | .032 | .047 | .064 | 1.89 | .88 | .37 |
| 7 | .33 | .014 | .037 | .005 | 1.99 | .59 | .37 |
| 8 | .23 | .023 | .033 | .005 | 1.90 | .47 | .36 |
| 9 | .29 | .023 | .035 | .005 | 1.77 | .50 | .39 |
| 10 | .34 | .019 | .041 | .017 | 1.33 | .63 | .46* |

* Made from Copper Cliff slag

Heat No. 3 had to be remelted due to its higher carbon content, and was divided in two and mixed with pig forming part of Heats Nos. 8 and 9.

*Table 11.—Physical Tests of Some of the Above Heats.*

| Heat No. | Tensile Stress lbs. per sq. in. | Yield Point lbs. per sq. in. | Elongation % in 2". | Reduction. % | Remarks |
|---|---|---|---|---|---|
| 1 | 69,440 | 52,192 | 35 | 62.6 | Forged. |
| 4 | 67,648 | 52,192 | 35 | 62.6 | Forged. |
| 1 | 69,440 | 58,240 | 31 | 55 | Heated to 1425° F. Air cooled. |
| 4 | 70,560 | 58,240 | 30.5 | 55 | Heated to 1425° F. Air cooled. |
| 1 | 72,800 | 53,760 | 34 | 55 | Heated to 1425° F. Quenched in oil |
| 4 | 75,712 | 58,688 | 35 | 55 | Do. Drawn to 800° F. |
| 1 | 85,120 | 64,288 | 28% | 55 | Heated to 1550° F. Quenched in water. |
| 4 | 84,670 | 69,440 | 28% | 55 | Do. Drawn to 600° F |
| 1 | 87,360 | 70,336 | 24.5% | 44.6 | Heated to 1600° F. Quenched in water |
| 4 | 84,000 | 68,768 | 27.5% | 44.6 | Do. Drawn to 550° F |
| 10 | 141,120 | 88,480 | 7% | 8.5 | Do. Drawn to 550° F |
| 10 | 88,480 | 61,152 | 25% | 30.6 | Forged. |

*Table III.*

Physical Tests and Analyses of Nicu Steel Heat No. 6, made by Dr. Alfred Stansfield, McGill University; and comparison with Nickel Steel as per Specification for Plates and Shapes, Ontario Nickel Commission Report, Page 365.

| | Nicu Steel. | Nickel Steel. |
|---|---|---|
| Carbon | 0.37% | 0.45% |
| Manganese | 0.88% | 0.70% |
| Phosphorus | 0.064% | 0.04% |
| Sulphur | 0.047% | 0.04% |
| Nickel | 1.89% | Nickel 3.25% |
| Copper | 0.37% 2.26% | |
| Tensile Stress lbs. per sq. in. | 96,300 | 85,000 to 100,000 |
| Yield Point lbs. per sq. in. | 56,350 | 50,000 |
| Elongation on 9 in. per cent. | 18.7% | 16.2% |
| Reduction of Area per cent. | 36.3% | 25.0% |
| Tensile Strength | | 85,000 to 100,000 |
| Elastic limit not less than | | 50,000 |
| Elongation in 8 in. not less than | 1,600,000 / T.S. | Average 17% |
| Reduction of Area not less than | | 30% |

Nickel Steel Specification in connection with the fabrication of the large bridge to span the Mississippi River at Memphis:

*Table IV.*

Nicu Steel produced commercially at the Canada Cement Company's Steel plant, East Montreal, and tested by Dr. Alfred Stansfield,—in comparison with Nickel Steel of similar composition, as given in tabulated form on Page 387 Marked (C) and Page 416 marked (1) Royal Ontario Nickel Commission Report.

| | Nicu Steel Heat No.6. | Nickel Steel (C) Page 387 | Nickel Steel (1) Page 416 |
|---|---|---|---|
| | % | % | % |
| Carbon | 0.37 | 0.47 | 0.47 |
| Manganese | 0.88 | 0.86 | .... |
| Nickel | 1.89 | 2.15 | 2.92 |
| Copper | 0.37 2.26 | .... | .... |
| | lbs. | lbs. | lbs. |
| Yield Point | 52,800 | 52,000 | 56,000 |
| Tensile Stress | 96,500 | 93,000 | 95,400 |
| Elongation on 2 in. | 24.3% | 24.5% | 22% |
| Reduction of Area | 50.8% | 51.8% | 44.6% |
| Bending Tests 180° | Shewing no crack | Shewing no crack | .... |

*Table V.*

Results of the Royal Ontario Nickel Commission, Page 415. Table 3, obtained with Nicu Steel and Nickel Steel produced under exactly the same conditions during their investigation of the Colvocoresses process.

| | Nicu Steel Heat No. 2. | Nickel Steel Heat No 4. | Nicu Steel Heat No. 6. |
|---|---|---|---|
| | % | % | % |
| Carbon | 0.43 | 0.53 | 0.53 |
| Nickel | 2.10 | 3.43 | 2.45 |
| Copper | 1.20 3.30 | .... | 0.80 3.25 |
| | Lbs. | lbs. | lbs. |
| Elastic Limit | 82,600 | 77,400 | 80,000 |
| Tensile Strength | 110,400 | 115,400 | 111,600 |
| Elongation % on 2 in. | 22% | 20% | 19.1% |
| Reduction of Area % | 48% | 38.3% | 38.3% |

These steels were produced under the direct supervision of Geo. A. Guess, Professor of Metallurgy, University of Toronto, in conjunction with the Royal Ontario Nickel Commission.

Extracts from Prof. Guess's report:

"It is evident from the results shown in Table 3 that "these laboratory-made steels are of good quality."

"The value of this process of producing Nickel-Copper steel is based on the belief that copper may replace "a very considerable amount of the nickel in a 3.5 per "cent nickel steel without producing an inferior article, "which belief is, I think, well founded."

*Table VI.*

Royal Ontario Nickel Commission Report, Page 421, Comparison of Nicu Steel with Nickel Steel.

| | Nicu Steel. | Nickel Steel. |
|---|---|---|
| | % | % |
| Carbon | 0.44 | 0.46 |
| Silicon | 0.034 | 0.066 |
| Manganese | 0.50 | 0.70 |
| Phosphorus | 0.013 | 0.021 |
| Sulphur | 0.013 | 0.034 |
| Nickel | 3.62 | 3.36 |
| Copper | 0.48 4.10 | 0.10 3.46 |

The Physical Tests of the rolled natural steels showed:

| | | |
|---|---|---|
| Elastic Limit | 72,400 | 74,626 |
| Ultimate strength | 115,000 | 122,000 |
| Elongation in 2 in. | 22% | 16% |
| Reduction of Area | 51% | 34% |

In the annealed condition the results were:

| | | |
|---|---|---|
| Elastic Limit | 63,750 | 64,750 |
| Ultimate strength | 107,300 | 119,000 |
| Elongation in 2 in. | 25% | 17% |
| Reduction of Area | 48% | 37.5% |

*Table VII.*

Standard Specification New York Society of Automobile Engineers for 3½ per cent Nickel Steel.

| | Specification No. 23-20 | Commercial Nicu Steel produced at Montreal |
|---|---|---|
| Carbon | 0.15 to 0.25% | 0.20% |
| Manganese | 0.50 to 0.80% | 0.51% |
| Phosphorus | 0.04% | 0.006% |
| Sulphur | 0.045% | 0.03% |
| Nickel | 3.25 to 3.75% | 2.12% |
| Copper | | 0.40% 2.52 |
| | Rolled Annealed. | Forged Natural. |
| Yield Point | 40,000-50,000 | 52,190 |
| Reduction of Area | 65-40% | 62.6% |
| Elongation in 2 in. | 30-20% | 35% |

*Table VIII.*

| | Specification No. 31-40 for Nickel-Chromium Steel. | Commercial Nicu Steel produced from Copper Cliff slag. |
|---|---|---|
| Carbon | 0.35 to 0.45% (desired 0.40%) | 0.34% |
| Manganese | 0.50 to 0.80% (desired 0.65%) | 0.63% |
| Phosphorus | 0.04% | 0.017% |
| Sulphur | 0.045% | 0.041% |
| Nickel | 1.00 to 1.50% (desired 1.85%) | 1.33% Nickel 1.79% |
| Chromium | 0.45 to 0.75% | 0.46% Copper |
| | Rolled Annealed. | Forged Natural. |
| Yield Point | 40,000 to 60,000 | 61,150 |
| Reduction of Area | 50-30% | 30.6% |
| Elongation in 2 in. | 25-15% | 25% |

## COBALTCROM—ERRATA.

On page 79 of our last issue, under the head, "A New Cutting Steel," will be found the peculiar word "coalterom." In the MS. it was "cobalterom," in the first proof "colalterom": we corrected the error, but the typesetter took our correction for a deletion, with the result "coalterom." Unfortunately we were unable to see the final proof.

On page 18 of the February number we find: 3. "It operates at any small fraction of full load with appreciable reduction in efficiency." The "with" should of course, have been "without."

There are no doubt other misprints which have escaped our attention, and we shall be obliged if our readers will inform us of any they notice, so that corrections can be inserted.—Editor.

## HOW SLAG DIFFICULTIES WERE OVERCOME IN A CONTINUOUS COAL-FIRED BILLET HEATING FURNACE.

By H. S. GROVE, Plant Engineer, Dominion Bridge Company, Ltd.

The writer recently experienced difficulty in providing a satisfactory wearing surface for the delivery chute of a continuous coal-fired furnace used for heating the billets for the forging of 6 in. high explosive shells. The billets rolled down the inclined bed of the furnace in two rows, and at the delivery end were poked into an inclined V-shaped trough, at right angles to the length of the furnace, from which they were withdrawn by means of a hook-bar.

As originally installed, the wearing surface of this trough or chute was formed by three steel rails. But it was found that the rails burnt away rapidly, leaving a rough surface to which the molten scale clung in a continually increasing quantity, which was only removed after a stream of water had been directed upon it to cause disintegration, with a natural result that the brickwork of the furnace also suffered considerably.

A heavy cast steel chute was tried with no greater success. Finally the arrangement shown in the accompanying figure was adopted, and proved entirely satisfactory. It consisted of four 2-inch double extra heavy pipes arranged to form a V-shaped inclined trough connected at each end with headers made of 4 inch double extra heavy pipe. Right and left pipe buckles and nipples joined the 2 in. pipes to the headers. Cooling water was admitted at the lower header, and escaped from the upper header into a funnel. The space between the pipes was filled with fireclay, topped with "coronum concrete." It was found that the molten scale solidified on the cool surface of the pipes, and was easily removed by means of a scraper between the withdrawal of the billets.

## A PROBLEM IN LARGE HEATING FURNACES.

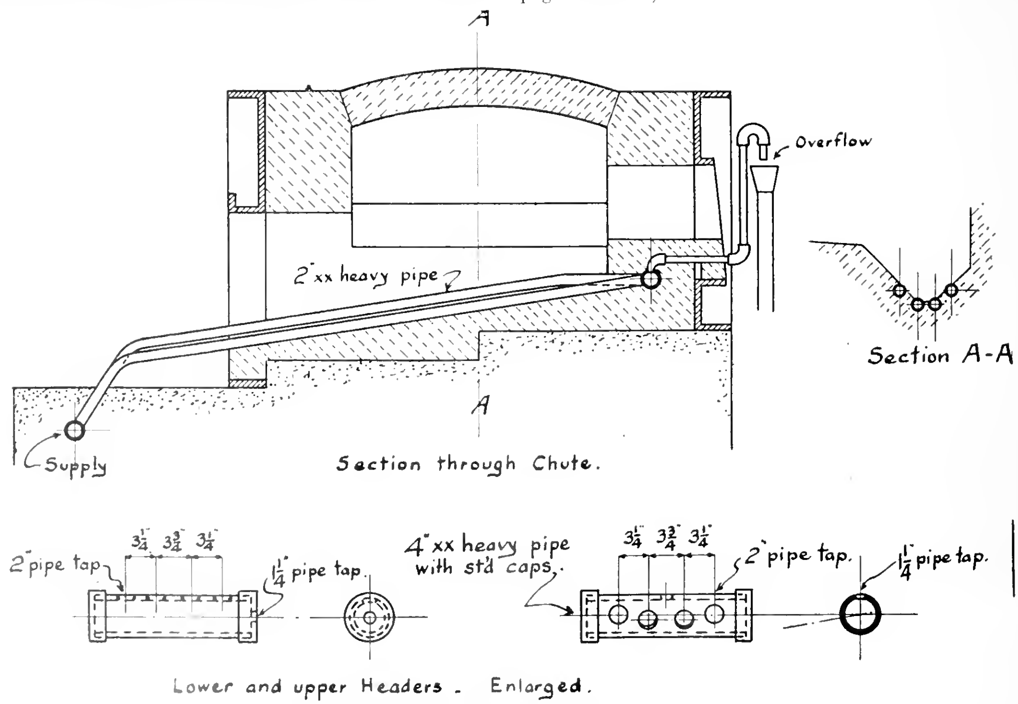
A problem has recently arisen in one of our Canadian plants which might prove of interest to our readers.

Twelve-inch steel channels are being heated in a sixty foot heating furnace. The furnace is of new construction but not novel in design, and was built by one of the best and most reliable furnace companies in the States. It is oil heated, and has a flat brick hearth with a salt glaze, on which the channels rest directly.

The channels are about thirty-five or forty feet long, but not much more than half in the furnace. They are drawn from the same end as they are charged, yet at times it takes a hoisting engine working almost up to capacity to start drawing them out of the furnace. It has been found necessary to get out a pusher at the opposite end of the furnace to start channels that are entirely inside the furnace. This trouble is apparently unique and is puzzling those concerned. It is supposed that molten oxide in the bottom of the furnace has collected and makes a kind of weld to a hot channel. If any further information about this kind of trouble could be given, together with a suitable remedy, there is no doubt it would be very acceptable to some of our readers.

The suggestion has been made to run water cooled pipes diagonally across the furnace for the channels to rest upon, but this would mean a big delay and expense.

(A similar problem and its solution appears on this page.—Editor.)




BILLET CHUTE FROM HEATING FURNACE.

# Defects in Ingots and Forgings

Messrs. Werner and Gordon Spencer are to be congratulated upon the matter contained in their paper on the above subject, and, when more space is at our disposal, we intend taking up in detail a few of the many interesting points they have raised. By classing the defects inherent in crude cast steel under six sections the authors have conveniently considered most of the troubles so well known to steel makers. It is not necessary for steel to be oxidized or blown before pin holes appear, it has frequently been demonstrated that the presence of dust in a cast iron mould will produce these defects, particularly near the base of an ingot. Blow hole trouble can undoubtedly be relieved by allowing time for the deoxidizing reagents to do their work, but in many cases it is impossible to allow this necessary time. In pouring 4.5 inch shell blanks an ordinary heat will produce from 450 to 500 billets, which means an equivalent numbers of openings of the stopper. Using circular tables to carry the moulds and keeping the ladle stationary was the most expeditious method of pouring these blanks and still it required from 1½ to 2 hours to empty a ladle. Even with steel on the "hot" side when it left the furnace, and rushing the operation as much as possible, it was always extremely difficult to prevent the metal freezing, or going pasty before the last mould was filled. It was thus impossible to allow extra time for chemical reactions once the metal was tapped. Too much reliance is placed on deoxidizers, in many plants, and it would be better to pay more attention to furnace practice and the getting of the steel into proper condition before tapping. Again virtues are frequently attributed to these "physics" that they have no claim to and when this was recognized the addition reagent was considered worthless, whereas if its legitimate function only had been claimed, and looked for, much useful work would have been accomplished by the reagent in question. The problem of welding up contraction cavities, or secondary pipes, opens up a wide field for discussion and very diverse opinions are held amongst leading metallurgists. But it is to be feared that metal once having suffered from the presence of such cavities could never be made as useful as metal that was originally free from them. That pouring temperatures have a marked influence on the solidity and freedom from excessive piping of ingots is freely acknowledged by all, but Canadian steel makers always had to labor under forced production conditions. These conditions invariably meant a metal on the "hot" side at first, about right during the middle of the heat, and a tendency to be cold towards the end. The first billets cast always showed a tendency to large crystal growth, but this was not detrimental in view of the fact that the steel had to be reheated for forging and thus underwent a certain refining of grain structure. Mould design and cooling conditions are interdependent and many schemes, devices, and designs have been tried out, but the best results will always be achieved where the cross sectional area at the bottom is much less than that at the top. For instance, it is almost impossible to produce a thoroughly sound six inch blank if cast of an even diameter for its whole length, on the other hand a blank for the same shell cast 6 31/32 at the top and 5 31/32 at the bottom with a slight increase in length to make up for lost weight will almost invariably be sound and homogeneous. The smaller area at the bottom naturally cools first and the ingot then cools uniformly from the bottom towards the top, the result being that the pipe and segregated material will be found well up in the portion that has to be discarded. There are various theories and explanations in connection with ghost line troubles, all of which we hope to deal with at some future date, but it may be said, in passing, that their detrimental influence has, in many cases, been grossly over-estimated. If the Montreal Metallurgical Association can keep up to the standard of this paper its sphere of influence will rapidly increase.

---

## HAMILTON NOTES.

The National Steel Car Co., Ltd., have participated in the big car orders placed by the Dominion Government this month. This company's share of the order is one thousand forty-ton box cars, having steel frame and superstructure, with wood sheeting, similar to those at present being manufactured. If material can be secured the company say they can complete this order in about ninety days, but like most other firms, they are having their own troubles getting material.

This company also has a large order for coal and ore cars for India, for the Bengal and Nagphur Railway. It is hard to say just how large this order is or will be, as it is continually being added to.

---

The B. Greening Wire Co., Ltd., have good orders for ship cable, on which they are working at present.

---

The Dominion Steel Foundry Company, Ltd., have about completed an addition to their machine shop, and are now commencing work on the foundation for a hundred-and-sixty foot addition to their annealing shop. This is to take care of large ship parts, for which they have considerable orders.

---

The annual meeting of the Hamilton Bridge Works Co., Ltd., was held on March 12th. Mr. Walter B. Champ was named managing director. Since Mr. Roy's death, nearly two years ago, the position of manager has been vacant, but Mr. Champ (then sec.-treas.), has been handling most of the work. Mr. Arthur Martin has been appointed treasurer in order to help ease the work now carried by Mr. Champ. Both these gentlemen have been with the firm for many years in about the same line of work, so the new appointments will not really mean much change in this institution.

---

The Burlington Steel Co. are busy on large orders for reinforcing steel.

---

The Steel Co. of Canada, Ltd., are making good progress with the operation of their plate mill; the output is increasing daily, and the quality still reported good.

The Wilputte Coke Oven Co. are rushing the coke ovens for the Steel Co. The latter company have arranged to rent the City steam shovel to excavate in the slag bank preparatory to driving steel sheet-piling for the foundation for their coal storage plant in connection with the new coke ovens.

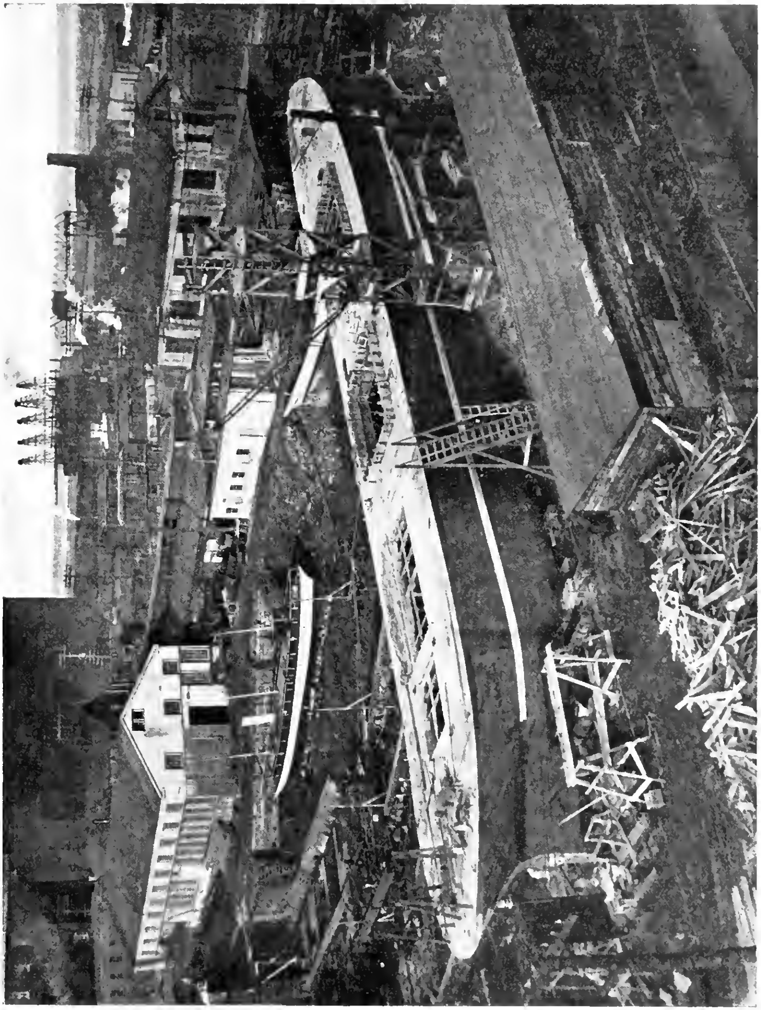
W. B. CHAMP
Managing Director Hamilton Bridge Works Co., Ltd.

Walter Baker Champ, who has for many years been secretary-treasurer of the Hamilton Bridge Works Co., and who was last week elected managing director and secretary of the company, was born in Hamilton, March 23rd, 1874. His entire business career has been with the Hamilton Bridge Works Company, having joined that firm when he was only 17 years old. He was appointed treasurer of the company when only 24 years of age, and seven years later he was made secretary-treasurer. Mr. Champ has been a director of the company since 1910. He is a member of the Hamilton Board of Trade, and was president of that organization for the year 1909. He is a member of the Canadian Manufacturers' Association, and served on the executive council of that association from 1909 to 1912. As managing director of the Hamilton Bridge Works Co. Mr. Champ succeeds the late R. Maitland Roy, Mem. Can. Soc. C.E. Mr. Champ has been acting manager of the company since Mr. Roy's death in July, 1916.

## COLD ROLLED AND COLD DRAWN STEEL.

It seems that a certain amount of confusion exists as to the difference between "cold rolled steel" and "cold drawn steel," and the two are frequently classed as one product. In reality there is a great difference between the two, they are made by different methods, have widely different natures, and are used for quite different purposes. Hot rolled (black) stock is used in the production of cold "rolled" steel, and is manipulated under very great pressure between heavy, hard, and highly polished steel rolls. Passage between these heavy rolls imparts a smooth finish, and exact size to the strip or bar. By this process the material is reduced in sectional area, and increased in length, but it retains the original black finish. The production of cold "drawn" steel is accomplished by an entirely different process, and supplies us with shafting, bars, and rods of great accuracy as to size, and of a smooth bright surface. To secure this product a bar of hot "rolled" steel slightly larger than the desired finished size is passed through what is known as a draw-bench, which is provided with a hardened steel die having an opening to correspond with the size of the material to be produced. By means of powerful gripping contrivances the piece is drawn through this die, which decreases the size and imparts the highly finished appearance.

In making cold drawn steel tube, by the Talbot-Stead process, a billet or blank is taken and pierced with a central hole; in this hole a mandril is placed and strongly attached by chains to one end of a drawing machine. The blank is gripped by powerful jaws and drawn away from and over the mandril at the same time that it is passed through successively smaller dies. The size of the mandril determines the bore of the tube, and the difference between the size of the mandril and the last die to be used regulates the wall thickness. To overcome the physical stress due to distortion careful and repeated annealing has to be resorted to.



"CONCRETIA" LAUNCHED MONTREAL, NOV. 1917

## MANITOBA STEEL FOUNDRIES, LIMITED.

At a meeting held in Winnipeg in June, 1916, it was decided to start a small foundry for the purpose of producing electric furnace steel castings to supply the demands of the middle west. Three causes contributed to this decision being made, the constantly growing demand for steel castings, the abundance of hydro electric power, and the available supply of steel scrap. It was also recognized that an excellent market was already in existance for there was no steel foundry between Owen Sound in the east and Vancouver in the west. Having mapped out a course of action, five acres of land were acquired at Selkirk, about 18 miles from Winnipeg, and a foundry building was erected 130 feet x 77 feet. This was designed so that it may be extended as required for fresh plant, and without interfering with the present lay out in any way. The company has at the present time one three-phase two-ton furnace, made by themselves, and one two-ton single-phase Snyder furnace installed. Besides these it has been decided to erect an-

other furnace to be in readiness to work as soon as a new motor generator, which is at present under order, shall be delivered. When these contemplated additions have been made the daily capacity of the plant will equal about 30 tons, the bulk of which will go into general castings for the railways and structural and machine shops, a contract has also been entered into to supply steel billets for rolling mill purposes, so that the maximum output of the plant is taken care of. Castings for Manitoba are now imported from Eastern Canada, under a freight rate of 90 cents per 100 lbs., or from American steel foundries, when they are subject to a duty of 35 per cent., plus the special war tax, and are also subject to a heavy freight rate. Beyond the main foundry building, all other necessary departments have been taken care of under separate roofs, and the general outline of the scheme shows thoughtful consideration, both as regards present requirements and possible future developments. Railway transit is convenient, and the company has the right of way to the navigable waters of the Red River, and therefore Lake Winnipeg. Having looked into the whole proposition upon the spot we are of opinion that the Manitoba Steel Foundries will supply a pressing need, and that they have started rightly in selecting the electric furnace of small capacity, in preference to larger units. Mr. Thomas Arnold, President of Taylor & Arnold, Montreal, is also President of the Manitoba Steel Foundries, Limited, with an executive staff at Selkirk and Winnipeg.

## PURE SHEET NICKEL.

### "The Aristocrat of Commercial Metals."

One of the most important developments undertaken and accomplished in this country to replace material formerly manufactured abroad has been the production of Pure Sheet Nickel in all widths and thicknesses.

Until a few years ago the many advantages of Pure Nickel had not been appreciated, and in consequence there were no adequate facilities for the rolling of this metal into large sheets. It was the practice for many years to use Nickel supplied by mines in Canada, the metal being shipped to European manufacturers for fabrication, and previous to the war practically all Nickel sheet, strip, and finished articles coming into this country of foreign manufacture were of the American ore worked by foreign concerns.

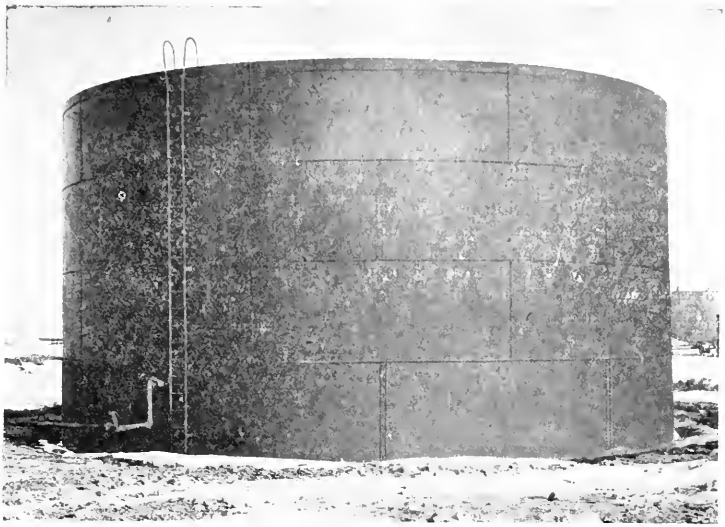
The superior qualities of Pure Solid Nickel cannot be confused with those of inferior metals frequently sold as Nickel, but which are invariably merely articles of steel, brass or German Silver with a thin nickel-plating which in a short time wears through, rendering the ware unsuitable and unsafe for use and of no value.

The danger of poisoning by verdigris is eliminated as pure Nickel does not rust or oxidize and the metal will not tarnish, as in the case of silver and some alloys, such as German Silver, Corrosion cannot occur even where the surface is injured and this is a decided advantage over the plated articles. Another possibility of poisoning is obviated which might result from traces of acid and other tarnish removers used to clean plated and copper food containers. Therefore, Pure Nickel has the decided advantage of safety with the additional proficiency over other metals of being practically everlasting, it requires no re-plating as with plated utensils, and abrasions on its surface will only serve to brighten the finish.

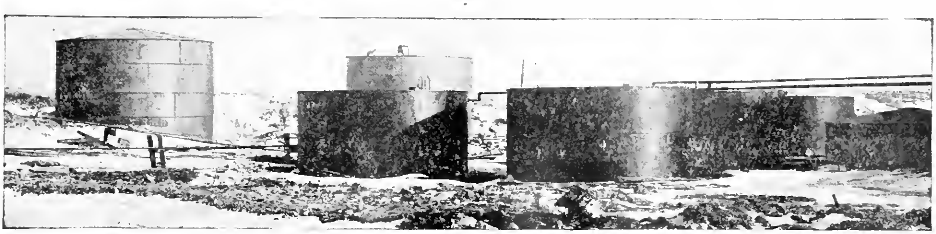
Pure Nickel because of its resistance to the corroding influence of chemicals, is invaluable in the chemical manufacturing field for many uses, and because of this property holds a conspicuous place in the metal world, being superior to copper and bronze and their alloys. In a word, it is practically immune to the action of all alkalies usually met with in ordinary, practical service. Large quantities of the metal have been used in the past year for the manufacture of nickel crucibles, used in chemical laboratories. There are a number of parts of chemical apparatus and machinery that must be made of non-tarnishable, non-corrosive metal. This is a practical application of a practical metal such as Pure Nickel, in a commercially practical way, and it can be used in the manufacture of these products on a commercially profitable basis.

Particular emphasis may be laid upon the attainment of producing Pure Nickel sheets of a very high tensile strength and in connection with this it is to be noted that no individual equipment is required for working the Pure Nickel, the same implements and metals being used as with German Silver and hard alloys. It has the characteristic of being homogeneous, very ductile and easily formed by spinning or stamping.

With a view to manufacturing sheet Nickel in a large way, Driver-Harris Company, Harrison, N. J., have provided the necessary facilities and equipment and are now in a position to supply a superior product in large quantities, at a cost which brings it within the range of a great variety of commercial uses.







## NOTES FROM NOVA SCOTIA.

Several severe storms in Nova Scotia during the past month have seriously interfered with transportation between Cape Breton and Western Nova Scotia, with the result that the plant of the Nova Scotia Steel & Coal Co. at Trenton has had to shut down several days each time, due to lack of coal and steel, but the supply of raw materials has been continuous of late, and the indications are that the output for the month will be a good average one.

Besides manufacturing 4.5 inch high explosive and 18-lb. shrapnel forgings, the company has resumed work on finishing shrapnel shells, and shipments of the latter product are expected to begin in the very near future. The forge department is also producing heavy tonnages of marine forgings and freight car axles.

The merchant mills also are said to be well booked on material entering largely into the manufacture of rolling stock for our various Canadian railroads, while plate for marine and structural purposes is being turned out by the company's plate mill.

With the heart of the winter past, and probabilities of finer weather hereafter, the prospects look very assuring for much larger outputs during the coming months.

"Scotia's" subsidiary company, "The Eastern Car Company," is also said to be making good progress on their various orders, and preparing to handle the large order recently received from the Canadian Government Railway.

The two 4.5 inch high explosive shell finishing shops of J. W. Cummings & Sons and the Albion Machine Company are working full force, and will have made good showings for the past month.

## GRAIN-SIZE MEASUREMENTS.

By ZAY JEFFRIES,

Metallurgical and Chemical Engineering Feb. 15, p. 185.

Many grain-size determinations by the method described by the writer, A. H. Kline, and E. B. Zimmer* have led to certain refinements in manipulation. Of the several methods tried, the following is recommended as the most satisfactory:

A circle 79.8 mm. diameter is drawn on the rough side of a ground-glass screen, the centre of the circle being near the centre of the rectangular section of the screen. This ground glass is mounted in a frame which fits a metallographic camera, the smooth side of the glass being on the outside. When the image of the specimen for grain-size determination is focused on the screen the circle will be plainly visible and its circumference should be well within the image.

When the image is properly focused the grains intersected by the circumference of the circle are checked and counted. Since the check marks must be made on the smooth side of the glass, a soft red pencil such as is used in laboratories for marking beakers and flasks will be found satisfactory. The marks used to indicate the boundary grains are usually short, straight lines intersecting the circumference of the circle and perpendicular to it. The completely included grains are next checked and counted, after which the red marks are erased from the glass with a dry cloth. The specimen can then be moved and other measurements made as desired. The idea of putting the rough side of the ground glass with the circle drawn on it to the inside of the camera was suggested by W. T. Burgoon.

In the early experiments the equivalent number of whole grains within the circle was obtained by adding 0.6 of the boundary grains to the completely included grains. The factor 0.6 was used as the result of about 200 determinations which showed an average factor of 0.58. The accuracy of the work involved did not justify the use of a factor of two figures, so 0.6 was chosen in place of 0.5.

I am pleased to state that further careful measurements show that the factor 0.5 is actually more nearly correct than 0.6. The factor 0.5 is more convenient to use, since the boundary grains (usually less than 50) can be divided by 2 instead of multiplied by 0.6. It is true that either factor gives results somewhat more accurate than a specimen can be sampled and in some cases more accurate than the grains can be distinguished, but we now have experimental justification for using the more simple factor.

**Table I.**

| Magnification Used = $m$ | Diameter of Circle in Millimeters | Multiplier to Obtain Grains per Sq. Millimeter = $f$ |
|---|---|---|
| Full Size | 79.8 | 0.0002 |
| 10 | 79.8 | 0.02 |
| 25 | 79.8 | 0.125 |
| 50 | 79.8 | 0.5 |
| 100 | 79.8 | 2.0 |
| 150 | 79.8 | 4.5 |
| 200 | 79.8 | 8.0 |
| 250 | 79.8 | 12.5 |
| 300 | 79.8 | 18.5 |
| 500 | 79.8 | 50.0 |
| 750 | 79.8 | 112.5 |
| 1000 | 79.8 | 200.0 |
| 1500 | 79.8 | 450.0 |
| 2000 | 79.8 | 800.0 |

The use of the factor 0.5 in place of 0.6 does not in any way affect the use of the table of multipliers from which to obtain the number of grains per square millimeter at any given magnification. If the equivalent number of whole grains within the circle measured at a certain magnification be multiplied by the number in the third column of Table I. opposite the magnification used, the product will be the number of grains per square millimeter.

A circle 79.8 mm. diameter has an area of 5000 sq. mm. If it is desired to use a rectangle in place of a circle for the determination, convenient sizes will be found in Table II.

**Table II.**

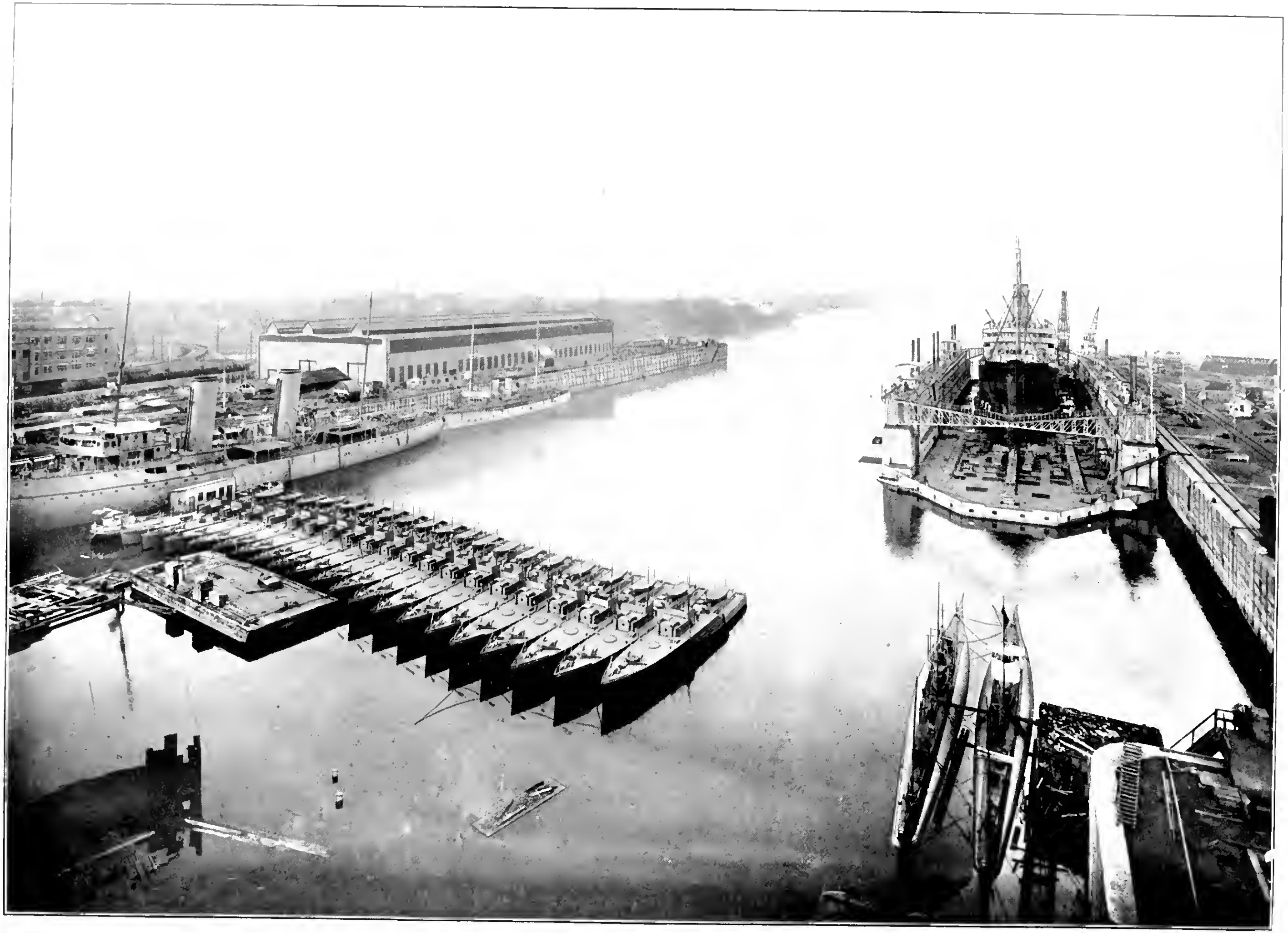
Convenient Sizes of Rectangles for Grain-Size Determination.

| | |
|---|---|
| 70.7 x 70.7 millimeters | 55 x 91 millimeters |
| 65 x 77 millimeters | 50 x 100 millimeters |
| 60 x 83.3 millimeters | |

Since each of these rectangles has an area of about 5000 sq. mm., the multipliers given in Table I. can be used for any of the rectangles in Table II., or any other rectangle having an area of 5000 sq. mm. To make a grain-size determination, with a rectangular in place of a circular area, the grains intersected by the

* Trans. A. I. M. E., Vol. LIV., pp. 594-607.

The author's method is recommended by the American Society for Testing Materials, Proceedings, Vol. XVII., 1917, Part I., Tentative Standards.—Editor.



FITTING OUT BASIN AND FLOATING DOCK.

# EDITORIAL

## MESSRS. CANADIAN VICKERS.

We consider that our readers and ourselves are both to be congratulated upon our principal article in this month's issue, and we tender our sincere thanks to the officials of the above Company for having placed such a possibility within our reach. Few laymen can have realized either the magnitude of this plant, or the strenuous efforts that are constantly in evidence within its walls. In our last issue we published an illustration of the first concrete ship built and launched on the American Continent, and during recent weeks the world's largest reinforced concrete ship has been launched at Redwood City, California. This vessel was 336 feet overall, 45 feet beam ,and has a carrying capacity of 5,000 tons. Fully loaded, with a displacement of 7,500 tons, she will have a speed of about 12 knots an hour. Triple-expansion engines of 1,750 h.p. and Scotch type marine boilers are now being installed. The vital importance of ship building of all and every class is forcibly demonstrated by the following statement and figures, which are copied from the Gazette of April 25th:

### Associated Press Cable.

London, April 24.—The Admiralty has announced the cessation of the weekly return of shipping losses and the substitution of a monthly report on the Thursday following the 21st of each month. The monthly statement will give the gross tonnage lost and the tonnage of sailings to and from ports in the United Kingdom.

A table issued to-night gives the losses of British, Allied and neutral merchant tonnage due to enemy action and marine risk since the beginning of 1917. The losses for the quarter ending in March, 1917, were:

British, 911,840, and Allied and neutral, 1,619,373.

For the quarter ending in June:

British, 1,361,370, and Allied and neutral, 2,236,934.

For the quarter ending September:

British, 952,938, and Allied and neutral, 1,494,473.

For the quarter ending in December:

British, 782,880, and Allied and neutral, 1,272,843.

The losses for the quarter ending in March, 1918, were:

British, 687,576, and Allied and neutral, 1,123,510.

Clearances in and out of the ports of the United Kingdom were very steady. The total for last March was 7,295,620 tons.

### Italy Lost Two Ships.

Rome, April 24.—One steamer of more than 1,500 tons and one steamer of less tonnage were sunk during the week ended April 20, according to the official statement on losses by mine or submarine, issued to-night.

With data such as this official statement as food for thought all must realize the overwhelming necessity for constantly increasing efforts to expedite shipbuilding. Articles such as the one published in this issue serve the double purpose of showing that the necessities of the situation are realized, and that every effort is being made to combat and overcome the serious condition disclosed. The tonnage actually launched and in course of construction may be small in comparison with the amount lost, but our statements serve to show the initial steps that have been taken and the ever-increasing results that may confidently be looked for in the near future. The inauguration of steel plate production in Canada cannot be of immediate assistance, but it is at least comforting to know that developments are taking place, and that an adequate supply of plates, channels, and other sections, of home manufacture, will be available at a time, which will be hastened in every possible way by the Dominion Iron & Steel Corporation. Montrealers may justly be proud of the plant that has grown so rapidly in their midst, and the most eulogistic praise is thoroughly deserved by all who have been identified with the development of the Canadian Vickers Shipbuilding Yard and Engineering Works.

---

## IRON AND STEEL SECTION OF CANADIAN MINING INSTITUTE.

In our last number we outlined the work that had been done in laying the foundation for a Canadian organization of the Iron and Steel Industry. Representatives of the organizing committee met the Council of the Canadian Mining Institute on the 5th of April, and ways and means were carefully discussed. The new Association has thus been constituted as a Section of the Canadian Mining Institute, and the executive committee will proceed with its organization and development.

The objects of the association have been indicated as follows:

(1) To afford a means of communication between members of the Canadian Iron and Steel Industry upon matters bearing upon their respective manufactures.

(2) To arrange periodical meetings for the purpose of discussing practical scientific subjects bearing upon the manufacture and working of iron and steel.

(3) For the dissemination of practical and scientific information amongst workers in the Iron and Steel Industry in Canada.

(4) To do such other things, compatible with the by-laws of the Institute, as may be found desirable in the interests of the Iron and Steel Industry of Canada.

Dr. Alfred Stansfield will act as Secretary during the organization period, and will be glad to supply information to all who may be interested, or to receive suggestions in regard to the services that this association can render to the industry.

## PRODUCER GAS.

In Perusing Mr. Percy G. Coles' paper on Producer Gas in Metallurgical Industries, one wonders why this relatively cheap form of gaseous fuel is not more generally used. In England, Mond Producer Gas is generated at a central station, and delivered to consumers under a pressure of 60 or 70 lbs. per square inch. It is used for some thirty-five or forty different operations, including: Running gas-engines, iron-melting, malleable annealing, sheet annealing, stamping, annealing, hardening furnaces, bar-heating, tube welding, enamelling, enamel drying, core drying, japanning, soldering, plating vats, water vats, and also for melting, welding, and annealing furnaces of various kinds. The highest temperatures used are required for iron-melting and tube-welding furnaces, and in the former case it is easy to maintain a temperature of from 1550 deg. C. to 1600 deg. C. Average analyses for 18 months gave:—

| | Per cent. |
|---|---|
| Carbon dioxide . . . . . . . . . . . . . . . . . | 17.40 |
| Carbon monoxide . . . . . . . . . . . . . . . | 10.31 |
| Hydrogen . . . . . . . . . . . . . . . . . . . . . | 25.55 |
| Methane . . . . . . . . . . . . . . . . . . . . . . | 3.25 |
| Nitrogen . . . . . . . . . . . . . . . . . . . . . | 43.49 |
| | 100.00 |

The highest bi-monthly calorific value for 18 months was 155.6 B. Th. U., which is 2.75 per cent above the mean value corresponding to the above analysis. The lowest bi-monthly calorific value for 18 months was 148.1 B.Th.U., which is 1.47 per cent below the mean value. When making comparisons between the cost of firing a furnace with coal or gas the third possibility, the use of oil as a heat-producing medium should be considered. We avoid entering upon the broad question of the thermochemistry of producer gas, but if the fuel used in producers is not carefully watched, it is easy for troubles to arise in metallurgical operations. As an illustration of this, a producer was working on a high sulphur coal at a time when a thirty-ton open-hearth furnace was running slowly, owing to moisture in the regenerative chambers, due to sodden ground. Heats were taking about 25 per cent above the normal time, and the steel produced had a sulphur content in excess of the permissable limit. After the furnace had been repaired, the heats were got out in the usual time, and the sulphur content dropped to within the allowable limits. The coal continued during the whole of this time of the same average analysis. The exposure of the molten metal, for an increased period, to the influence of the sulphur carrying gas was evidently responsible for the trouble with the finished steel. From the Siemens Gas Producer to the modern mechanical contrivance is a long step, but the limit of inventive skill has not yet been reached, and one can confidently look for further improvements in the near future. Again, for the economical use of producer gas the sensible heat must be utilized, in other words, the gas should be burned at the temperature at which it is produced, and it is sometimes difficult to do this where furnaces are situated some distance away from the producers. If cooling takes place, not only is this sensible heat lost, but tarry matters commence to deposit, and trouble at once arises. The value of a paper like the one under discussion cannot be over-estimated at the present time, when every possible effort must be made towards the economical use of available fuel supplies. In publishing matter such as this, we consider we are working on a subejct of national importance, and we always aim to create and foster an interest in such matters.

## THE FUEL SITUATION.

In our last number we gave an account of the two days' discussion of the Canadian fuel problem at a meeting of the Canadian Society of Civil Engineers in Toronto. We pointed out, on page 107, that the central and even some of the Western areas have been supplied with coal largely from the United States, although we have an ample supply of anthracite and bituminous coal in the West, and abundance of lignite in the central and western areas.

A logical outcome of this situation is the decision that no more hard coal may be shipped into the Canadian West. Winnipeg will receive a small supply, but western points must depend upon the domestic supply. We understand that this decision was reached at a conference between western coal operators and fuel control officials at Ottawa.

In the past the purchase of coal for the areas in question has been left until the fall, a time when East-bound cars are almost unobtainable, and in consequence the coal supply was brought westward from the United States instead of eastward from British Columbia. The new regulation will necessitate an earlier purchase of coal, and will result in a more regular and therefore a more economical operation of the coal mines in British Columbia.

Apart from this special regulation, C. A. Magrath, the fuel controller for Canada, has issued an order whereby no consumer may be supplied with more than seventy per cent. of his estimated normal needs for the year ending 31st March, 1919. Consumers are further recommended to lay in their supply as early as possible.

The fuel shortage last winter, although partly due to accidental breakdown of transportation facilities, was fundamentally caused by the diversion of ships, men and materials to military purposes. The situation in this respect is likely to get worse instead of better, and even with every improvement that can be effected in the production, distribution and use of fuel, a considerable part of the shortage will have to be met by a more economical and restricted use of fuel for domestic purposes.

In this connection we may mention that natural gas may no longer be used in the Hamilton district for industrial purposes. This is a natural outcome of the gradual exhaustion of the supply and the need of ren-

dering the domestic users, as far as possible, independent of imported fuel. Natural gas is an ideal fuel both for industrial and domestic purposes, but it is more essential for the latter because industrial concerns are better able to substitute oil fuel or producer gas. The fuel stringency will make it increasingly necessary for fuel users to employ bituminous coal in place of anthracite, and this can be done most efficiently by large scale users who can employ efficient appliances for the purpose.

## BRITISH COLUMBIA AND THE IRON AND STEEL INDUSTRY.

The pioneers of the Iron Industry in British Columbia are making strenuous and sustained efforts to develope and utilize the various ore deposits of their Province, and a measure of success seems likely in the near future. It will be wise to gather all possible data and to consider the proposition from every point of view before inaugurating the initial plant. The quantity, quality, and accessibility of ore supplies, the cost and suitability of fuels, the facilities for transport, and a central position as a distributing point from which to reach available markets, should all receive the most searching consideration. Upon the satisfactory solution of these problems depends the future success of the undertaking, and from all available information we are led to believe that no detail is being neglected. Beyond the economic welfare of British Columbia the satisfactory establishment of this industry would have a beneficial influence upon the Dominion, and would be a means of developing natural resources, and of finding employment for many returned soldiers after the war. A deputation of influential men from British Columbia is at present at Ottawa with the object of laying their schemes before the Government, and also to advance arguments in favour of certain bounties. The representative character of this deputation will be gathered from a perusal of the appended names:—

His Worship, Mayor Gale, of Vancouver.

His Worship, Mayor Vance, of North Vancouver, also representing the district of North Vancouver, the North Vancouver Board of Trade, and the district of West Vancouver.

S. F. Bledsoe, representing the city of Victoria and Vancouver Island.

George G. Bushby, President of the Manufacturers' Association, and President of the Metal Trades Emplayers' Association of British Columbia.

S. T. Howe, representing the municipality of Point Grey, B.C.

W. McNeill, representing the British Columbia Branch of the Canadian Manufacturers Association.

Capt. Worsnop, representing the Mining District of Kamloops.

F. S. Swales, representing the Grandview Chamber of Commerce, Vancouver.

In the memorandum they have laid before the Privy Council, they state that the Government of British Columbia has established a bounty of \$3.00 per ton on pig iron of local manufacture, but that other steps are necessary to place the production of such material upon an assured basis. The results achieved by Eastern Canadian iron and steel makers are attributed to the beneficial influence of the bounties paid from 1883 to 1912, and it is contended that similar treatment, if applied to British Columbia would produce equally satisfactory results. As an additional argument in favour of a renewal of some sort of bounty, the actions of other Governments are cited: The Commonwealth of Australia is paying a bounty of \$3.00 per ton upon pig iron. The Government of Japan pays a bounty of \$10.00 per ton on all steel used in the construction of steamships, and France has established a steel bounty of \$28.00 per gross ton for home built steamships. The delegation points out that British Columbia has endorsed its conviction that the winning and smelting of ore for the production of pig iron can be accomplished, but that the conversion of this metal into iron and steel of merchantable quality will require something more than provincial assistance. The memorandum, previously referred to, shows the Minister of Mines, for the Province of British Columbia, to be heartily in favour of rendering every possible assistance, and deals with the supplies of iron ore immediately available. It is also stated that the demands of a blast furnace producing 1,200 tons per day could be met for many years from known deposits. The various official and private reports dealing with the matter are given as references, and these include papers on the ore supply, the quality and quantitl of fuel, and of the limestone fluxes. As regards the cost of production it is argued that after the initial stages have been passed and the industry properly organized, it will be possible to produce pig iron in British Columbia at a lower price than it could be secured from any other centre. It is estimated that basing calculations upon pre-war conditions, and taking figures referring to 1911, the aggregate of British iron and steel products sold in such markets as should naturally be tributary to a British Columbia source of supply, amount, in round figures to \$125,000,000. These products were only such as could be reasonably manufactured by a well organized industry, such as it is hoped to establish in British Columbia. Taking part recently in a debate in the House of Commons, Mr. R. J. Manion (member for Fort William and Rainy River) dealt with the iron ore deposits of Canada and the development of all natural resources, and advocated increased efforts being made to utilize all Canadian minerals. In a later issue we hope to quote somewhat fully from the statistics and statements contained in Mr. Manion's speech for the widespread publication of such information can only be beneficial. In the Vancouver "World" for March 16th Mr. John Fraser, of New York, contributes an article dealing with the prospects of an Iron and Steel industry if established in British Columbia, and in his opinion the raw materials exist n sufficient quantity, and market demands would justify the erection of a modern iron and steel producing plant. From the available accumulated data, there seems every reason to consider that the prospects of such an undertaking, so far as they are affected by a supply of raw materials, seem quite satisfactory, and it is highly probable that the near future will see a works actively employed upon the production of iron and steel. If the united efforts of the energetic and enthusiastic men interested in this matter can control success, then success will be the final word to be written about the manufacture of iron and steel products in British Columbia.

## STEEL VESSELS OF STANDARD TYPE WITH 1800 H.P. ENGINES FOR U. S. NAVY.

The following is part of an article in the Buffalo News, April 30th:

The Ferguson Steel and Iron Company has broken ground for a shipyard on the Buffalo river, opposite the foot of Hamburg street, a yard that promises large development. At the outset of work, the yard will build vessels for the United States navy, but eventually it will be equipped for building all types of steel craft. Nothing will be attempted in the way of concrete construction.

The plans call for the laying of the first keels for the government by July 1. Finally, they contemplate construction work that will go far to restore Buffalo's prestige as a shipbuilding centre. For there were days when the largest vessels plying the Great Lakes were launched from Buffalo yards.

Captain James E. Ferguson, president of the Ferguson Steel and Iron Company, was recently detached from the U. S. signal corps at the request of the navy department to undertake the building of steel boats, for which there is an urgent demand. In speaking of the project to-day, he said he had long in mind construction work of this character in connection with the steel and iron plant.

The first vessels we will build will be 154 feet long and 1000 tons burden—all of standard type. They will have engines capable of generating 1800 horsepower. From keel to truck they will be Buffalo-made. Most of the parts will be fabricated in the Ferguson yard and mills. The parts that cannot be made there will be constructed in other Buffalo plants.

Edward P. Butts of Springfield, Mass., an engineer of large experience will be manager of the shipbuilding department of the Ferguson works.

This shipyard will occupy about seven acres of land. That, with the acreage of the steel and iron plant, gives the Ferguson works about 30 acres for their operations. The extent of the work undertaken by the yard will depend on the size of the organization that Captain Ferguson and Mr. Butts are able to assemble. It is hoped at the outset to have a force of 750 men. About September 1 from 250 to 300 men a month will be added to the operating force.

"We intend to make work as attractive as possible for our men," said Captain Ferguson. "As soon as possible, we will establish courses in shipbuilding for men who are eager to advance themselves and for young fellows who seek the opportunity to become skilled in the trades attached to the industry."

## STEEL CASTING INSPECTION CRITICISED.

Inexperienced, critical and faulty inspection is claimed to be delaying the production of steel castings for the government and for the purpose of speeding-up output, the Steel Founders' Society of America has recommended the establishment of a central inspection bureau. This plan would make it possible for one corps of men to make inspections for all departments of the government. In addition, they would devote all their time to steel castings with the result that because of their experience they could exercise discretionary powers not now possible. It has been the experience of all steel foundrymen that many cases arise in which castings meet the spirit of the specifications, but vary in some detail with the letter of the standard requirements. Because of inexperienced inspection, hundreds and thousands of steel castings have been allowed to accumulate until the red tape at Washington could be unwound to get some special ruling. Furthermore, the percentage of rejected castings is out of proportion with commercial practice. The British government found it desirable to combine its inspection forces and inspection was expedited further by restricting it to samples instead of going into detailed examination. Here, nothing but the inspection of the casting itself will suffice. In addition, the stamping of the heat number on each casting is a needless operation that harks back to the days when our gold-laced ordnace officers devoted their time to devising ways and means for making it almost impossible for manufacturers to produce according to outlined specifications. However, we are now at war. The time has arrived for action. These traditionary practices should be pigeon-holed and a few common-sense methods should be introduced. The number of inspections to which castings are subjected in steel shops is a joke. Why castings should be inspected immediately after shaking-out, no one in the foundry business has been able to fathom. The added handling thereby imposed on the shop greatly retards the cleaning and finishing operations, and the congestion slows-up production generally. And steel castings must not be welded! At least many of the so-called government inspectors believe this to be a heinous crime. . . . If the inspectors are without knowledge of this important subject, they should be given a course of instruction on what defects may and may not be welded before they are inflicted upon the steel foundrymen of the country. An immediate unification of all steel casting specifications for the various departments of the government is essential to the prosecution of our war program. If the diversified commercial interests of the country can abide by one steel casting standard there is no reason why the petty differences of the various government departments cannot be co-ordinated—at least for the period of the war—sufficiently to permit of the adoption of one set of specifications for all government steel casting purposes.—The Foundry.

## BOOK REVIEWS.

In this number we give the first of a series of reviews of books that should be found on the shelves of many of our readers. In this column, while we expect to review new books on the metallurgy of iron and steel and on kindred subjects that may be of interest to our readers, our special idea is to develop and keep up a descriptive catalogue of the standard books dealing with each branch of the Industry. Thus we have selected, for our first review, "The Blast Furnace and the Manufacture of Pig Iron," by Robert Forsythe, which was published in 1907, but is still a standard work. We know that this undertaking is somewhat ambitious, and that there are many pitfalls in our path, into some of which we shall undoubtedly fall. We hope, however, that our work in this direction will assist many of our readers in gaining scientific and technical instruction in their work.

# CANADIAN VICKERS AND SHIPBUILDING IN CANADA

A speech, at the opening of Parliament, by the Premier was published in the Montreal Star of March 20th, from which we quote as follows:—

"I come next to the question of shipbuilding and come to that next for this reason, that although we may raise troops and although we may provide food, nevertheless the troops cannot be transported overseas to perform their service and the food cannot be made available for Great Britain and the Allied nations unless there are means of transporation across the Atlantic.

Before alluding to what the present government has done in its shipbuilding policy, I think the House will be glad to know what has been done by the British Government through the Imperial Munitions Board, and what is being done at the present time. The Imperial Munitions Board have undertaken to construct, and I believe all these ships are now under construction or completed, forty-three steel ships of a tonnage of 211,300, deadweight, and forty-six wooden ships of a tonnage of 128,800 deadweight. The cost of the steel ships is $40,000,000, the cost of the wooden ships is $24,500,000, or $64,500,000 altogether. The total number of ships is sixty-nine, and the total tonnage is 340,-100. The first vessel, a wooden vessel, will be launched in the month of May and put immediately into commission.

I have asked the Minister of the Naval Service to give me a memorandum of what has been done in carrying out the policy upon which the present administration embarked last autumn. An appropriation of $25,000,000 has been authorized, so far as Council was able to authorize it, for the present year, and a memorandum, which I shall take the liberty of reading to the House, is as follows:

Sir Robert read this memorandum, which stated that the government expects to complete this year four cargo steamers of a combined tonnage of 23,500. For next year the programme calls for the commissioning of fifty new ships, with an aggregate tonnage of 235,-000. There are three types of vessels, one of 3,000 tons, one of 5,100 tons, and one from 8,000 to 10,000 tons. All are cargo vessels of standard construction and design. Thus at the end of 1919 Canada's total contribution to Allied shipping will be approximately 575,-000 tons. Apart from the munitions board expenditure on new shipping, the government has authorized a total appropriation for this year, of $25,000,000.

The steel has been purchased at the price fixed by the government for the steel required by the United States Shipbuilding Board. These prices are substantially lower than the prices the Canadian shipbuilders have been obliged to pay from time to time during the past twelve years, which represent a very large saving in the construction price of ships. The purchase of this material in the United States was made necessary by reason of the fact that the plates and shapes required for the construction of ships are not at the present time manufactured in Canada. The manufacture of all materials required for the construction of ships, more particularly plates and shapes, is, however, under consideration by the government, and it is hoped that the material for this purpose eventually will be manufactured in Canada."

Since the above was published a contract has been let to the Dominion Iron & Steel Corporation, under which they are to produce the plates, angles, channels, and other sections necessary for shipbuilding. When so much interest was being taken in the matter we decided to get all available information, and have devoted a large portion of this issue to an article upon the Canadian Vickers works. The erection of these shops was commenced early in 1914, and the yard was in operation in January, 1915. The amount of money invested is in the region of $12,000,000, and the number of employees is about 3,000. About 35 acres of land are occupied, and considering how short a time the plant has been in operation its record is one of which any organization may rightly be proud.

As frontispiece we use a photograph of the Fitting Out Basin and Floating Dock; the latter is capable of lifting 25,000 tons, and is the largest steel floating dock in America. It was designed by Clark and Stansfield, London, England, and was built by Vickers, Ltd., of Barrow-in-Furness. To the right of the illustration and in front of the dock are two submarines; over towards the left is a small fleet of armed motor boats, and behind one has a view of the boiler and engine machine shops. Twenty-four submarines have been constructed for Allied Governments.

Beyond the primary business of shipbuilding and its closely allied industries the firm has been engaged upon munition work and Fig. 1 shows the battery of hydraulic presses which were used for the forging operation. Altogether contracts for upwards of 1,000,000 shells have been completed.

Plate I. was photographed from a position looking down into the Dry Dock, and depicts a fleet of 30 armed motor launches. During the winter of 1916 the dock was temporarily covered in, and the floor space used for constructing these boats, which were afterwards launched by submerging the dock. A total of two hundred and fourteen of these boats has been completed.

Plate II. shows one of the motor launches being loaded on to a transport, preparatory to leaving for the other side, and Fig. 2, shows six of them loaded on trucks ready to leave on the railway journey to the coast.

The floating crane used in loading is the property of the Harbour Commissioners, Montreal, was built by Vickers, Ltd., Barrow-in-Furness, has a lifting ca-

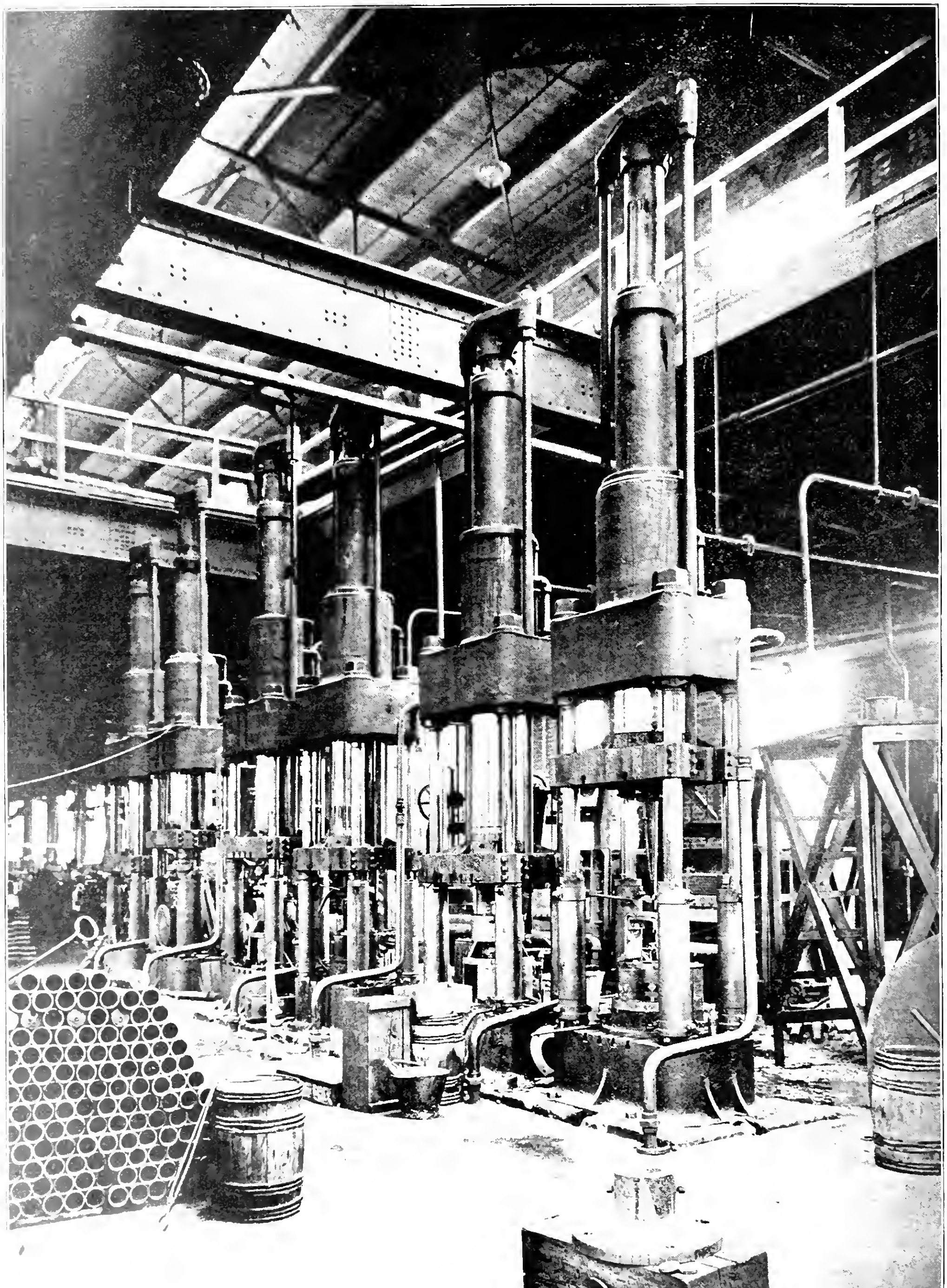


Fig. 1. Battery of Hydraulic Presses.

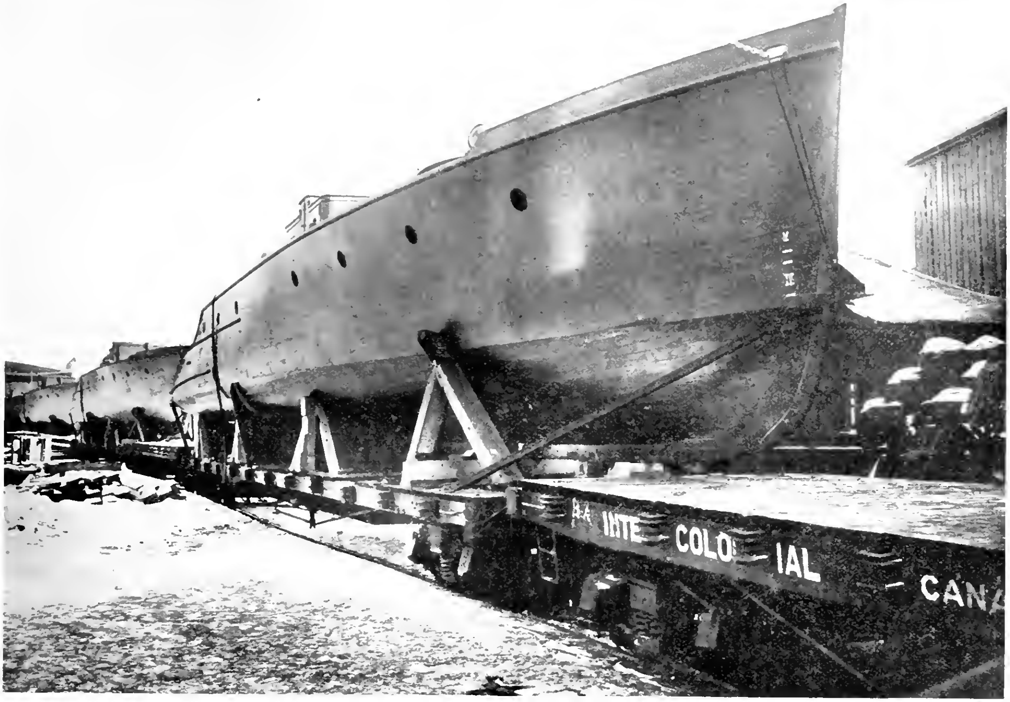



Fig. 2.—Armed Motor Launches on Trucks.

pacity of 75 tons, and constitutes a very valuable asset not only to shipbuilding, but to the Port of Montreal in general.

A very different type of shipbuilding is illustrated in the next photograph, Fig. 3, which is that of an icebreaker. This boat was originally intended for local service, and was christened the J. D. Hazon, but was afterwards sold to the Russian Government, and went overseas. She is one of the largest icebreakers ever built, and at the present time is the heaviest boat of her type afloat. Her engines are capable of developing 8,000 H.P.

The illustrations in Figs. 4 and 5 may be studied in conjunction, the former shows a 7,000 ton cargo steamer in course of construction, and the latter a sister ship as it was being launched. These vessels are of Lloyds' highest classification, fitted with all the most modern appliances for the rapid handling of cargo. The photographs show two out of six which are being built for the British flag, all of which will be handed over, together with two for the Canadian Government, during the current year. The latter will be the first item from this firm in the Canadian programme as outlined by the Premier.

In addition to the eight ships referred to, five more will be laid down in the yard this year. This means an average production of 60,000 to 70,000 tons of cargo carrying capacity per annum. The vessel illustrated on Fig. 6 is the first ocean going steel cargo ship built and launched in Canada, and completely equipped in one yard with main engines and boilers, auxiliary machinery and fittings made in Canada, with the exception only of the steel plates, boiler furnaces and anchors. The next picture, Fig. 6, shows a twin-screw dredger, and one of the largest ever built. This was designed for the Canadian Government for operating in the north channel of the St. Lawrence. It is self-propelled, with twin screws, and completely equipped with hoppers, and also for discharging into scows. It can dredge its way to a depth of 55 feet. Owing to the pressure of work incidental to the war the completion of this boat had to be postponed.

Plates, numbers 3 to 7, show five ship's berths, each occupied by a vessel in a different stage of construction. Owing to the courtesy and kindness of Messrs. Canadian Vickers, this photograph was taken specially for our article, and shows the condition as it is to-day. Such an illustration will enable the outsider to realize what is actively being accomplished day by day on the banks of the St. Lawrence.

Fig. 7 shows a marine engine on the beds for testing.

Fig. 8 shows the two halves of a lake steamer as they reached the Canadian Vickers wharf, and Fig. 9 shows the same two halves being closed up for joining. Twelve of these boats were brought from the lakes and joined up here preparatory to going into ocean service.

The Imperial Munitions Board have placed an order with this firm for 28 water-tube boilers, and Fig. 10

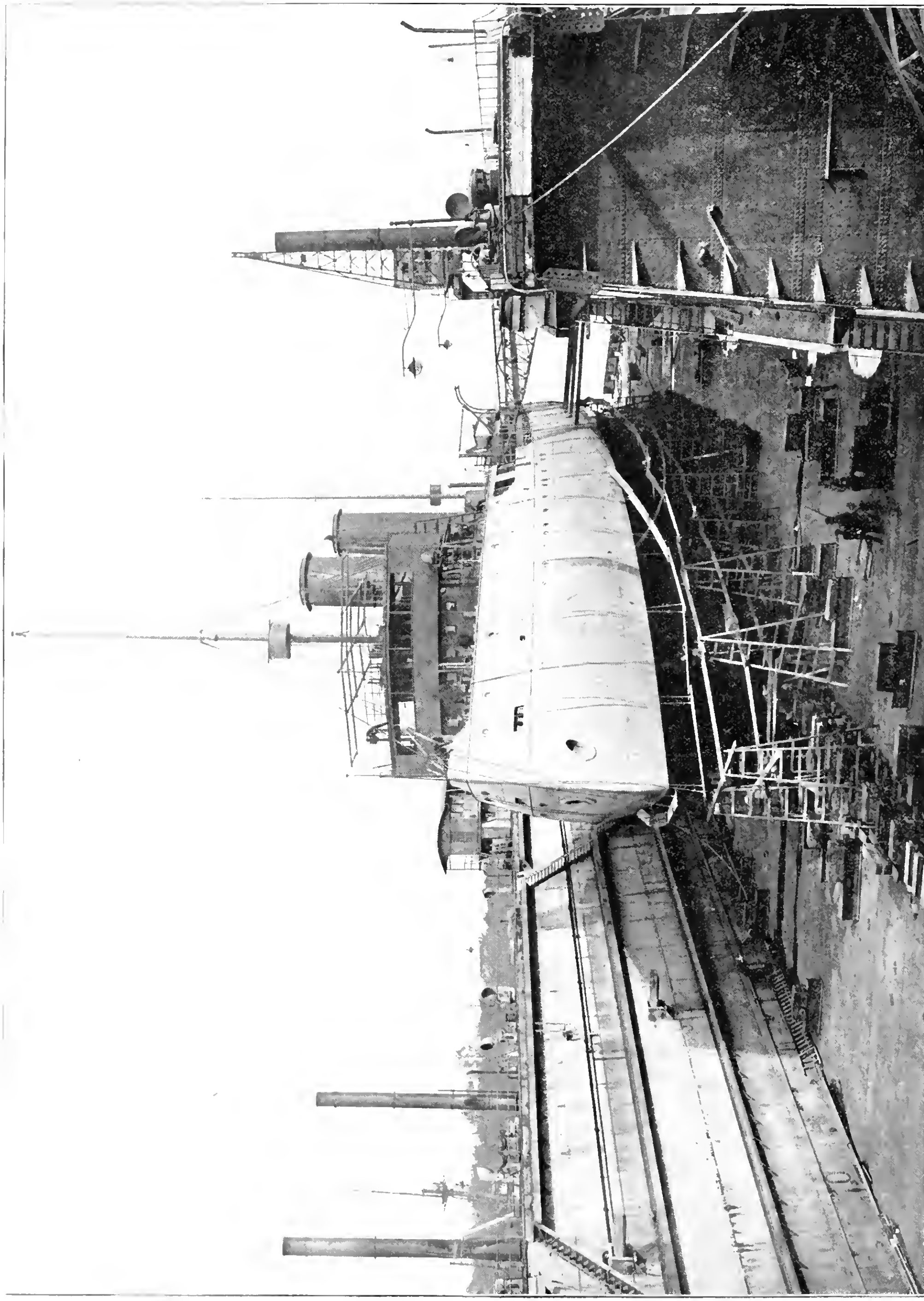


Fig. 3.—Ice-Breaker in the Dry Dock.

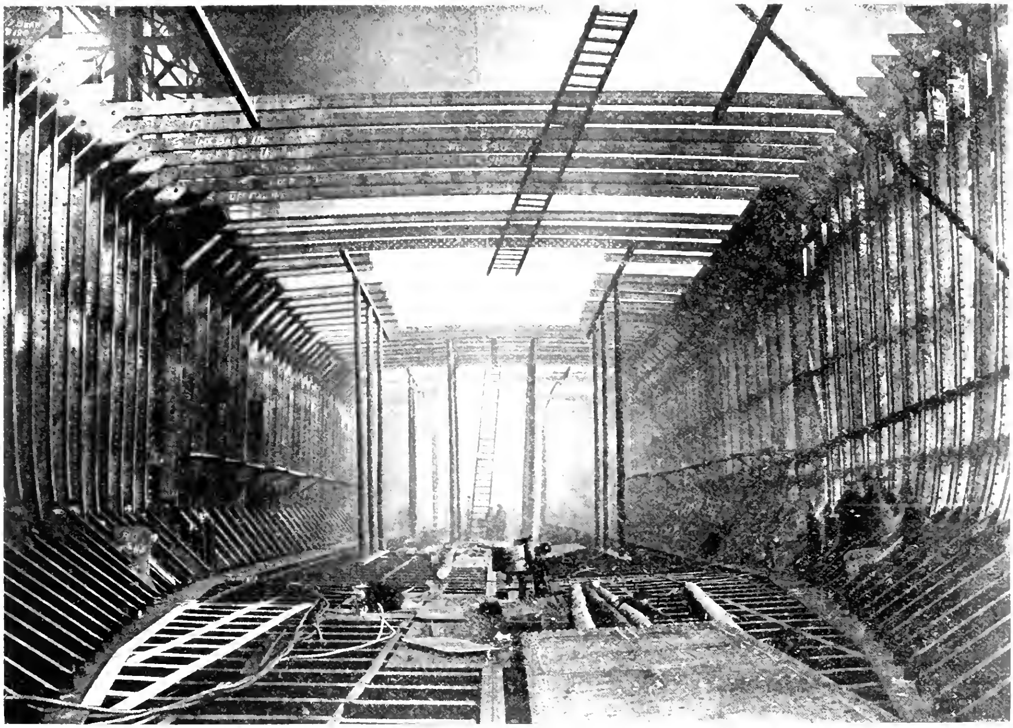


Fig. 4. 7,000 Ton Cargo Steamer Under Construction

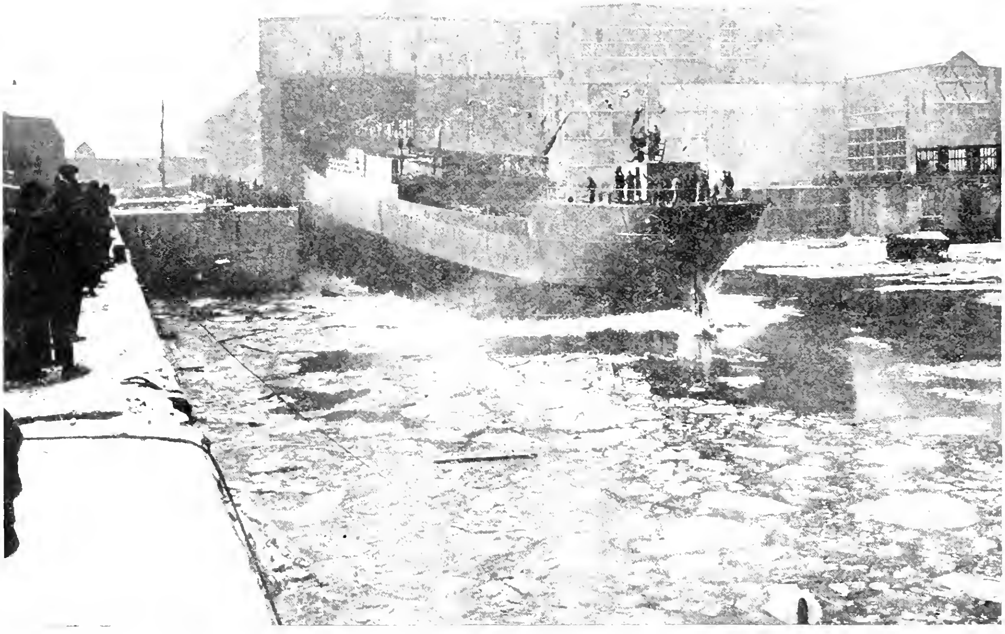


Fig. 5. 7,000 Ton Cargo Steamer Being Launched

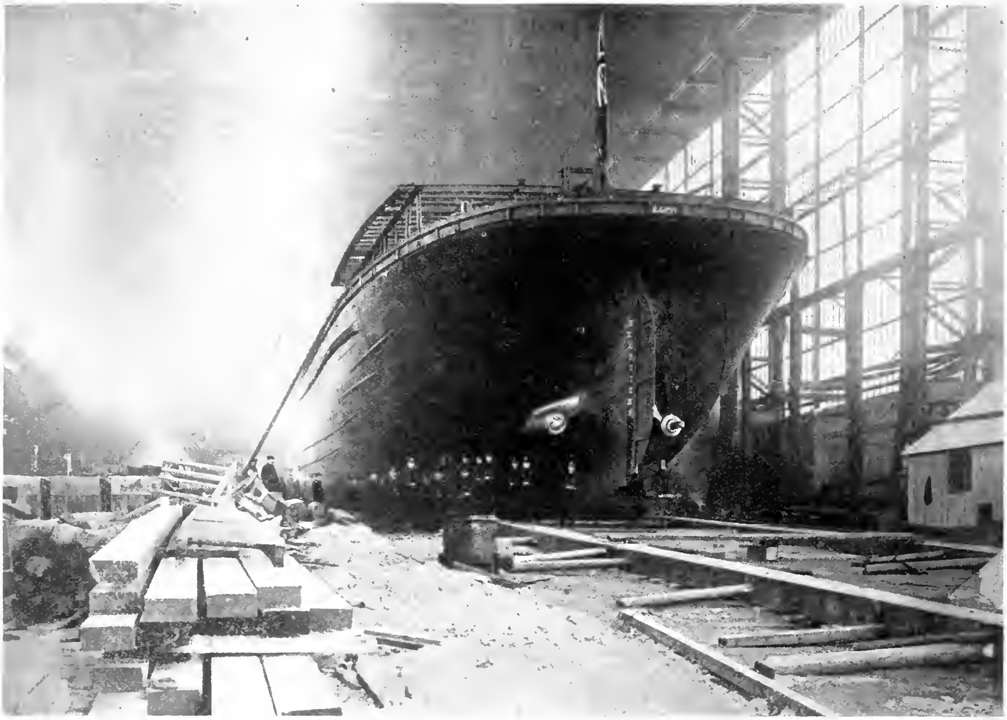


Fig. 6.—Twin Screw Dredger.

shows one of these already completed, and the balance are being turned out at the rate of from 6 to 8 per month.

The shop in which deck machinery is assembled is well illustrated by Plate 8, in which can be seen some of the various types of machines which are being turned out in large numbers. This is the shop that was used for shell forging, but all the presses have now been dismantled so that room could be found for an auxiliary deck machinery shop. Auxiliary machines such as cargo winches, cable windlasses, and steering gears of the highest quality, and the latest British standard and design are being turned out in large numbers. This shop can produce 600 of these machines per annum.

Quite recently a British cruiser was overhauled and repaired here, and the repairs included the machining of the main crank shaft, which in itself was no simple matter. The principal shafting lathe was used for the shaft, which was 17 inches in diameter, and 42 feet long, coupled in two 21 feet lengths, and of the four throw type. The lathe on which this work was done is the largest in Canada, if not on the American Continent, and the fact that the work could be done on the St. Lawrence, is a measure of the standard to which these works were constructed. Two other cruisers have undergone repairs at this yard during the past two years.

Amongst the various lines of work executed at this plant may be mentioned:—

17 steel mine sweeping trawlers, the last three of which were laid down, completed and ready for sea in 5 weeks.

26 wooden drifters.

4 steel digesters, 64 feet high, 18 feet in diameter, and of 1⅜ inch plate; these are amongst the largest ever built in Canada, or elsewhere, and are now installed at the Ha Ha Bay Sulphide Corporation's plant at Ha Ha Bay, Quebec.

The following work is now under construction:

6 cargo vessels of 7,000 tons dead weight.

1 cargo vessel of 8,100 tons dead weight.

1 cargo vessel of 4,300 tons dead weight.

These are all of the latest Lloyds' classification. The boilers and machinery for these ships are included with the contracts for the hulls, and are being carried out in the yard. The main engine shop is fully occupied on marine engines up to 3,000 H.P. for cargo vessels. The boiler shop is busily engaged on Imperial Munition contracts for 28 water tube boilers required for vessels building elsewhere in Canada, and also upon boilers of the Scotch type for use in cargo vessels.

It is gratifying to know that orders are booked to the full capacity of the plant, both for Canadian vessels and for export to the States, until well on towards the end of 1919.

At present 15 cargo winches are being produced per week, in addition to steam steering gears, hand steering gears, and anchor windlasses.

At the present time the yard is fabricating steel work for 8,000 ton boats, at the rate of one in six weeks, and it is only shortage of labour that prevents this result being increased. A complete programme has been framed for similar work during the next two years, and all the material necessary has been secured.

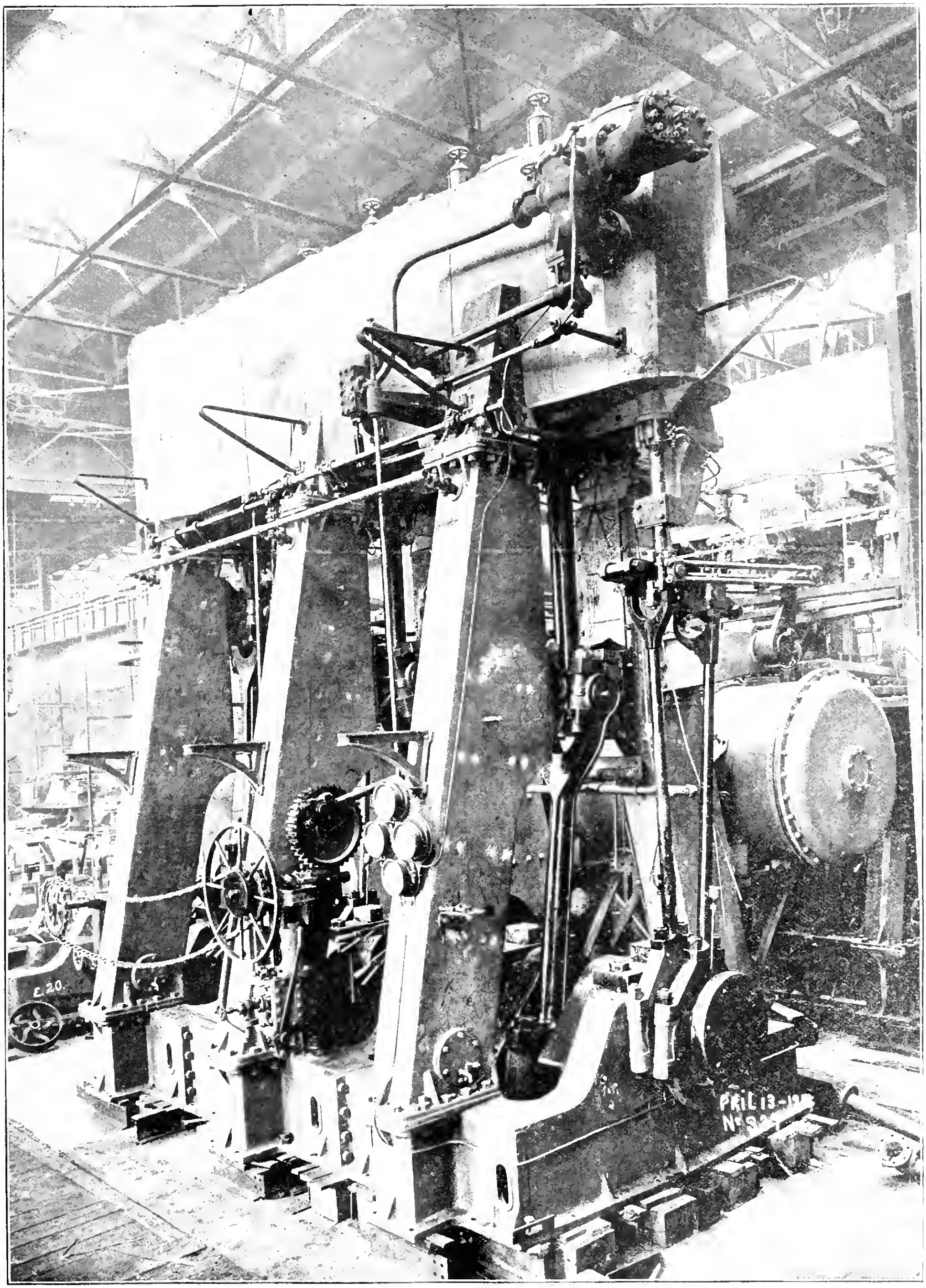


Fig. 7.—Marine Engine on Bed Ready for Testing.

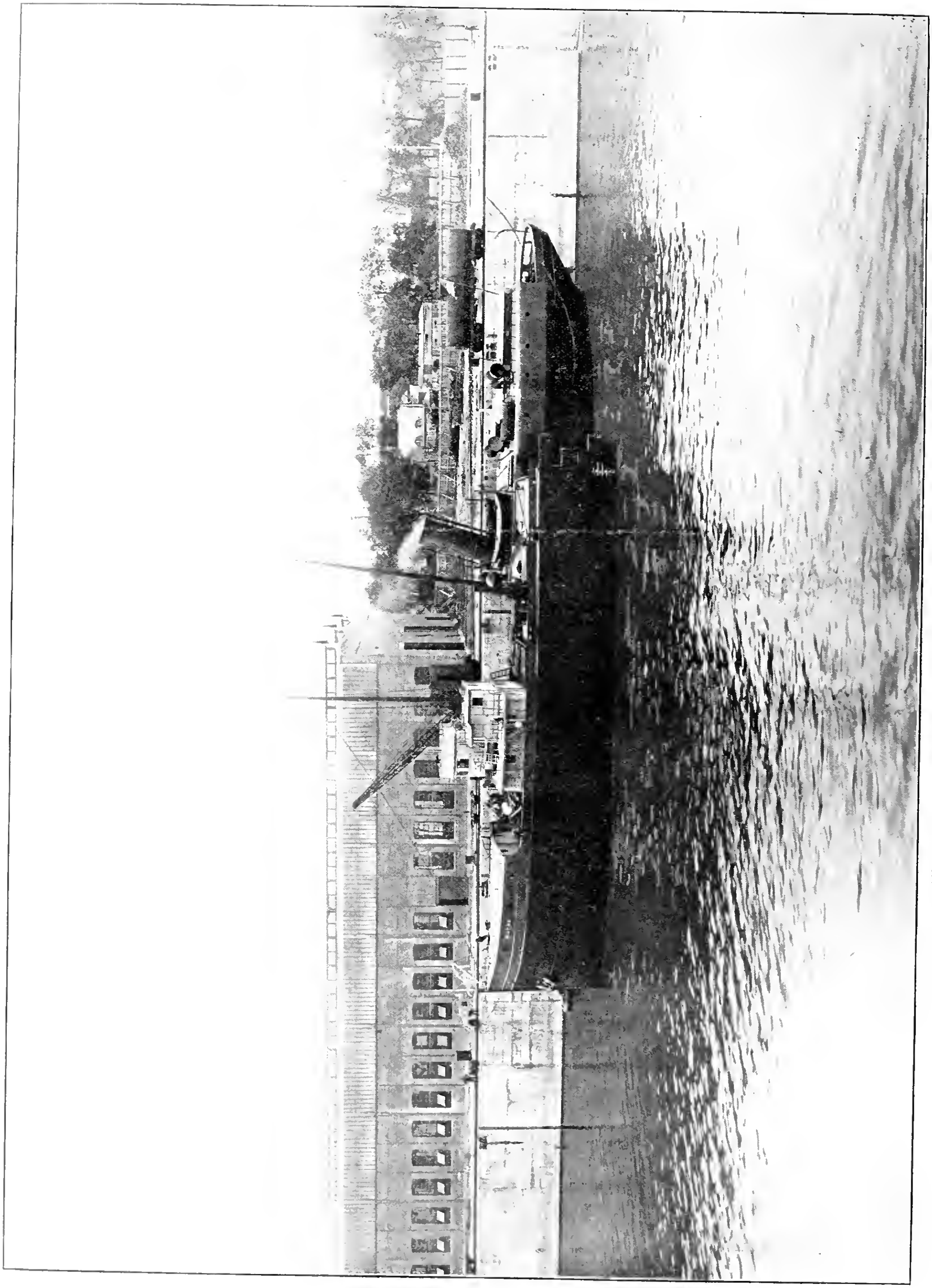


Fig. 8.—Two Halves of Lake Steamer as Received.

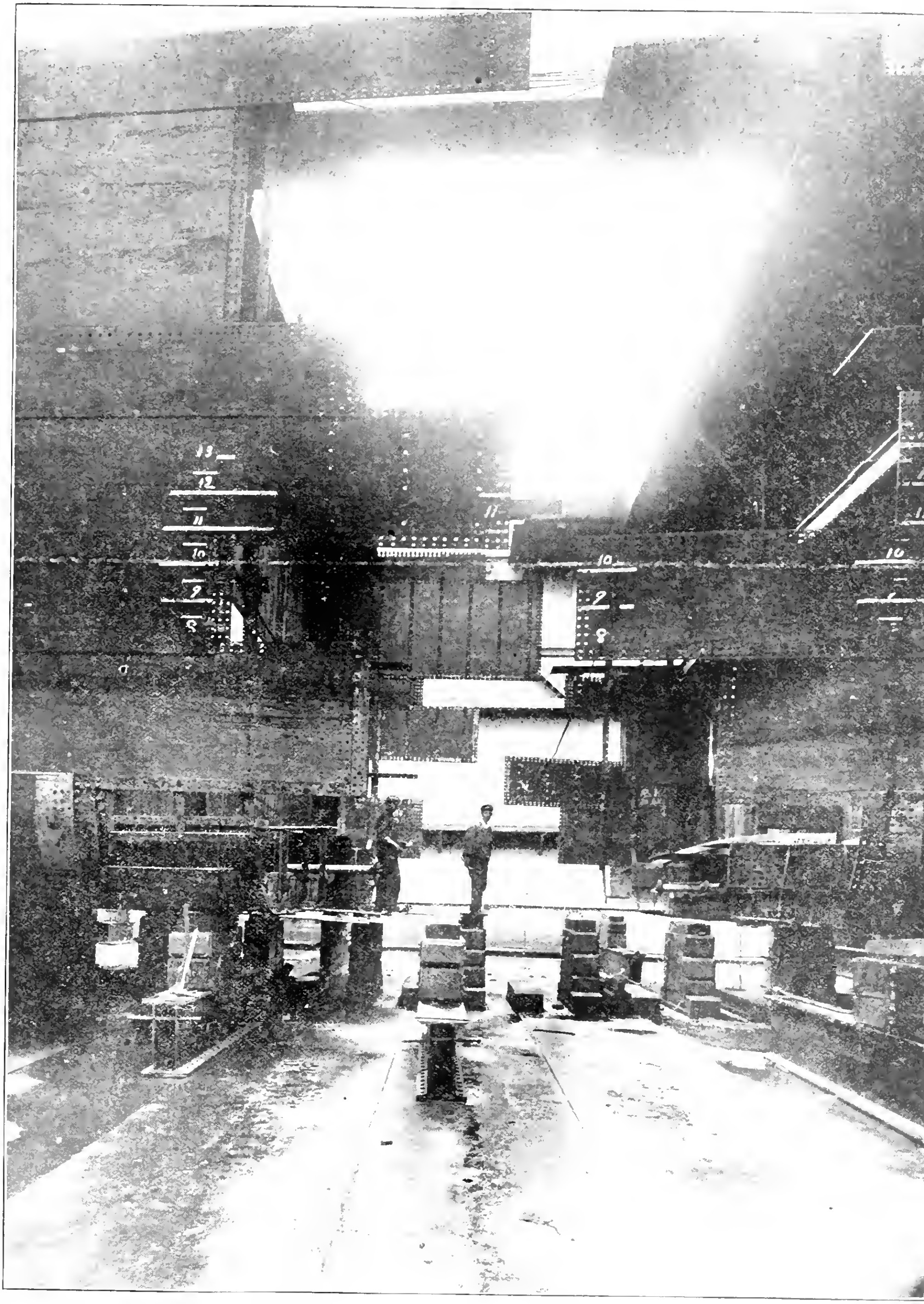


Fig. 9. Two Halves of Lake Steamer Being Joined Up.

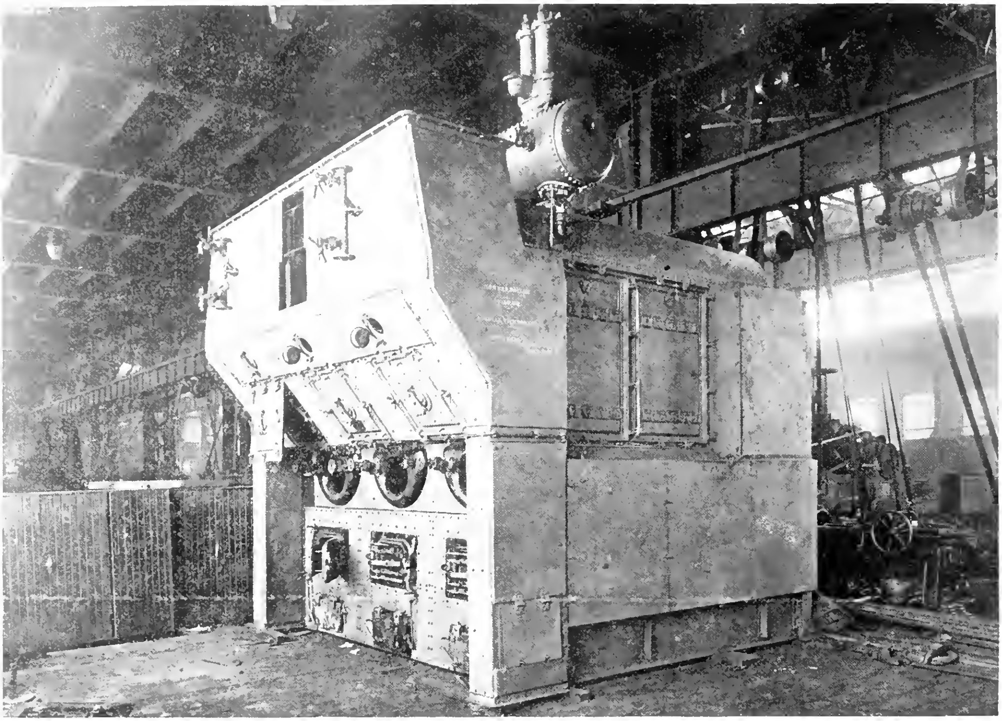


Fig. 10. Water Tube Boiler.

## MEASURING COKE OVEN GAS USED IN SOAKING PITS.

Increasing quantities of surplus gas from by-product coke oven plants are being consumed in various processes in steel mills and it is desirable to have an accurate and reliable measurement of this gas. For this purpose the Thomas meter has been applied, which measures the quantity of gas in standard units, such as cubic feet without any calculations or corrections for pressure and temperature, although these may vary through wide ranges. The total quantities (in cubic feet) are shown on an integrating meter and the rate of flow is shown graphically on a curve drawing instrument. The graphic chart obtained from this instrument is very useful to the superintendent of a coke oven plant, showing him at a glance the amount of gas being used for fuel in the coke ovens over any period, with variations in quantities clearly indicated.

The meter is installed in a housing which replaces a portion of the gas pipe line. The principle of the Thomas meter is that it measures the heat capacity of a gas electrically. The amount of electric heat necessary to raise a standard unit two degrees is used as a measure of the gas flowing through the meter. The electricity for heating the gas can be conducted on comparatively small wires, consequently the meters showing the amount of gas used can be placed in the superintendent's office or other desired location, which may be several hundred feet from the meter proper.

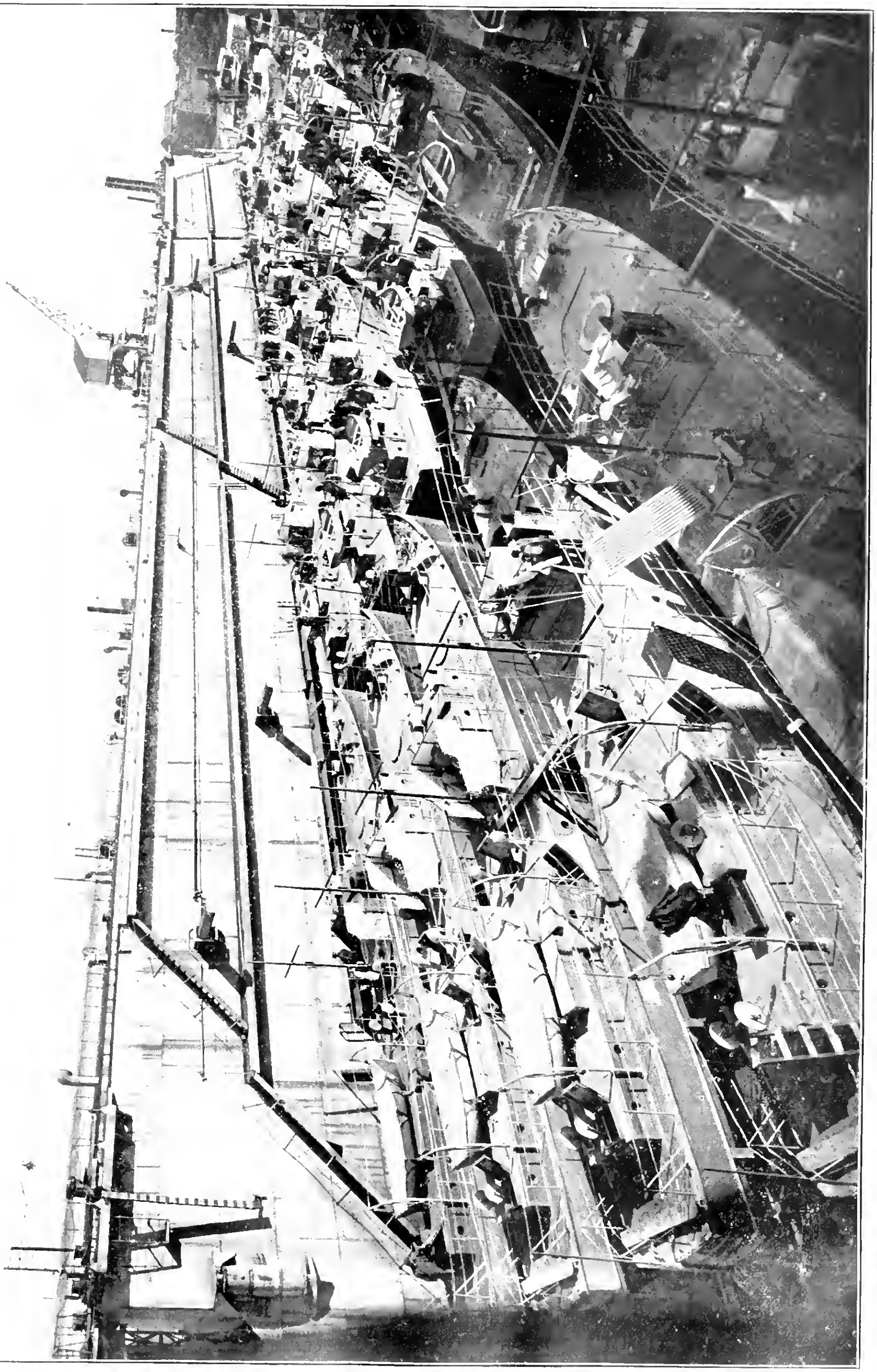
The graphic chart shows him at a glance just how much gas is being used at any time in the soaking pit building. The complete Thomas meter and recording panels are made and installed by the Cutler-Hammer Manufacturing Company of Milwaukee, Wis.—Metallurgical and Chemical Engineering.

---

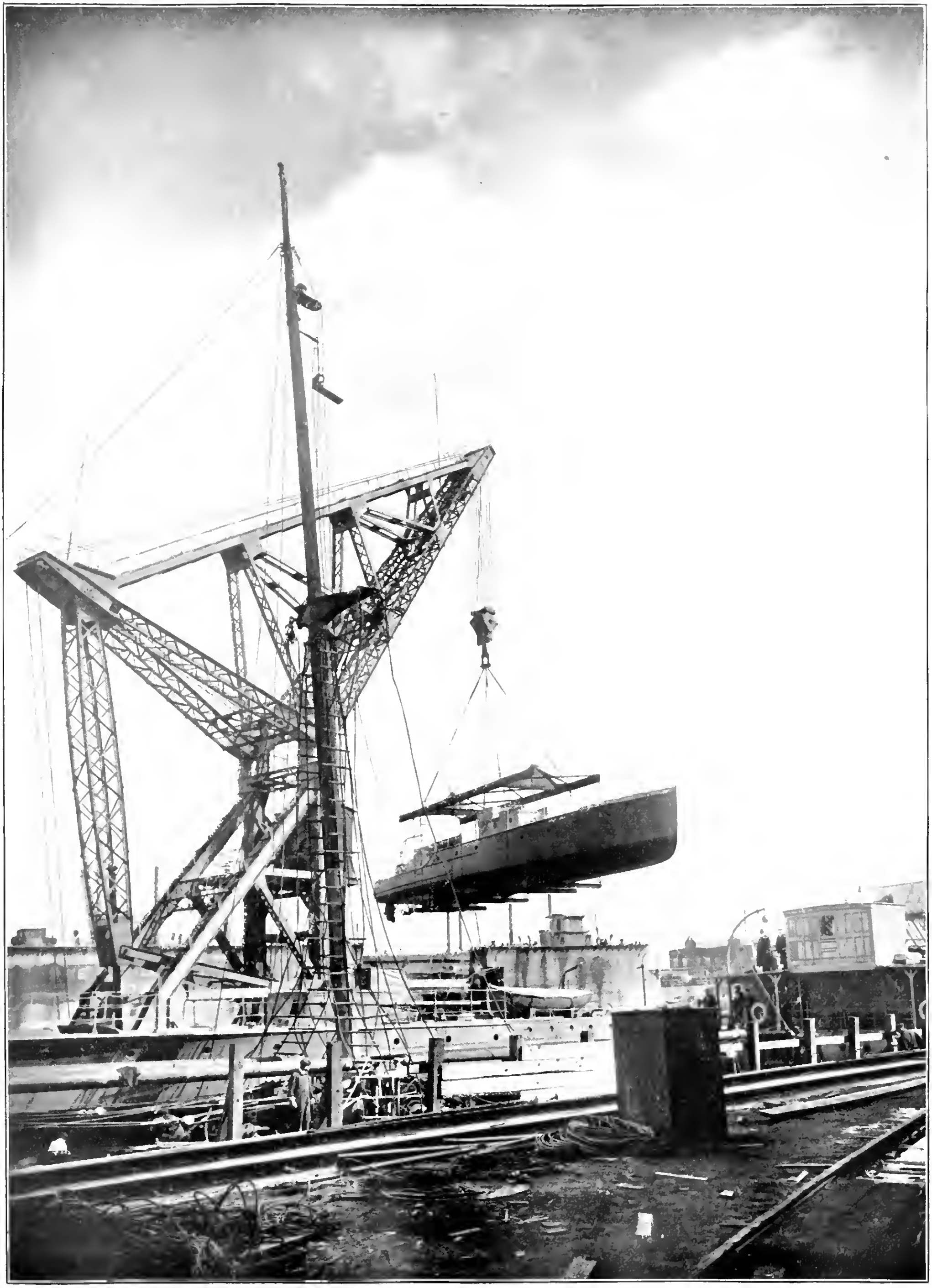
Another storage dam is to be erected by the Quebec Streams Commission, of which Mr. O. O. Lefebvre is chief engineer. This dam will be at Lake Brule, ten miles from Beaupre, P.Q., and sixteen miles northeast of the hydro-electric plant of the Laurentian Power Company, on the St. Anne River. The dam will give additional water power to this company. The scheme consists of a stone-filled wooden dam, 225 feet long at the crest, and two small earth dams. The pressure face of the wooden dam will be at an incline of 45 degrees. The dam will rest on solid rock.—Electrical News.

---

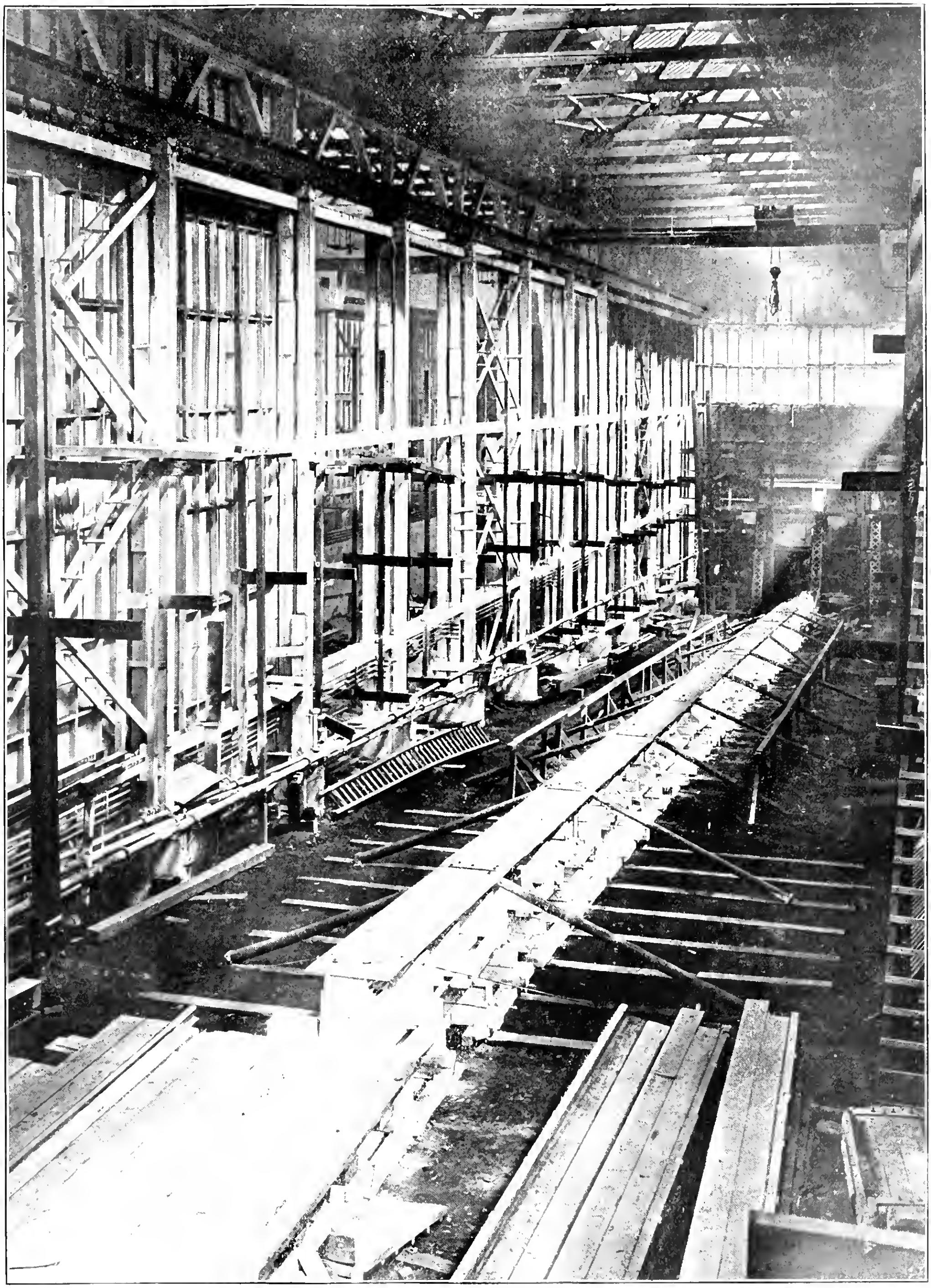
A new high-speed steel has been patented by a German company. The patent specification states that the steel shall contain carbon, 1.2 per cent; manganese, 1.2 per cent; silicon, from 0.1 to 0.3 per cent; chromium, from 3 to 10 per cent, and cobalt, 1.5 per cent. This material is said by the inventors to be an improvement upon a similar steel, which they patented last year, containing molybdenum. In its manufacture the molybdenum is omitted and the percentage of manganese and chromium is increased.—American Machinist.



CANADIAN VICKERS.
Plate Number 1 Dry Dock containing fleet of 30 armed motor boats.

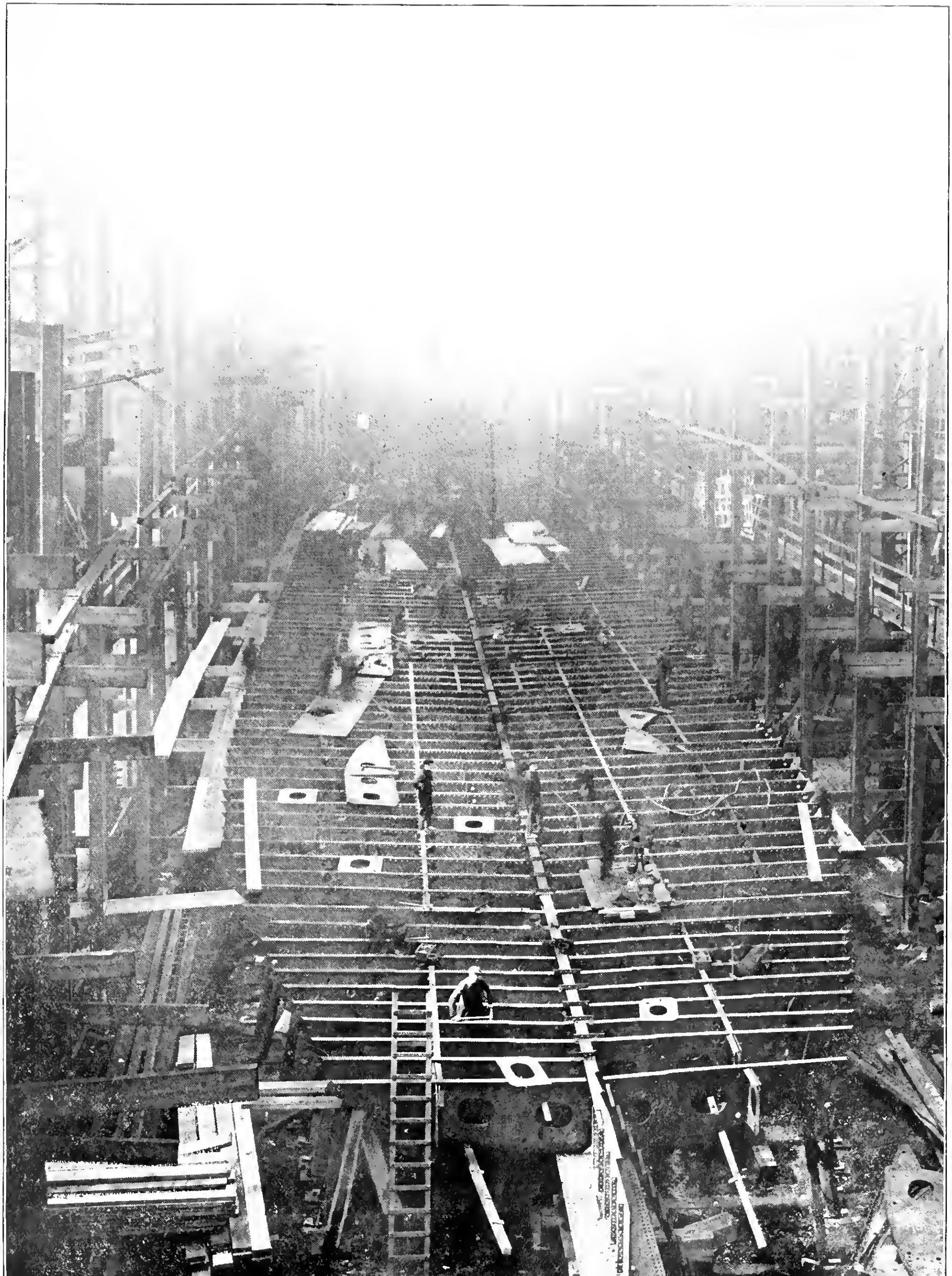


CANADIAN VICKERS.
Plate Number 2—Motor Launch being loaded on to transport.

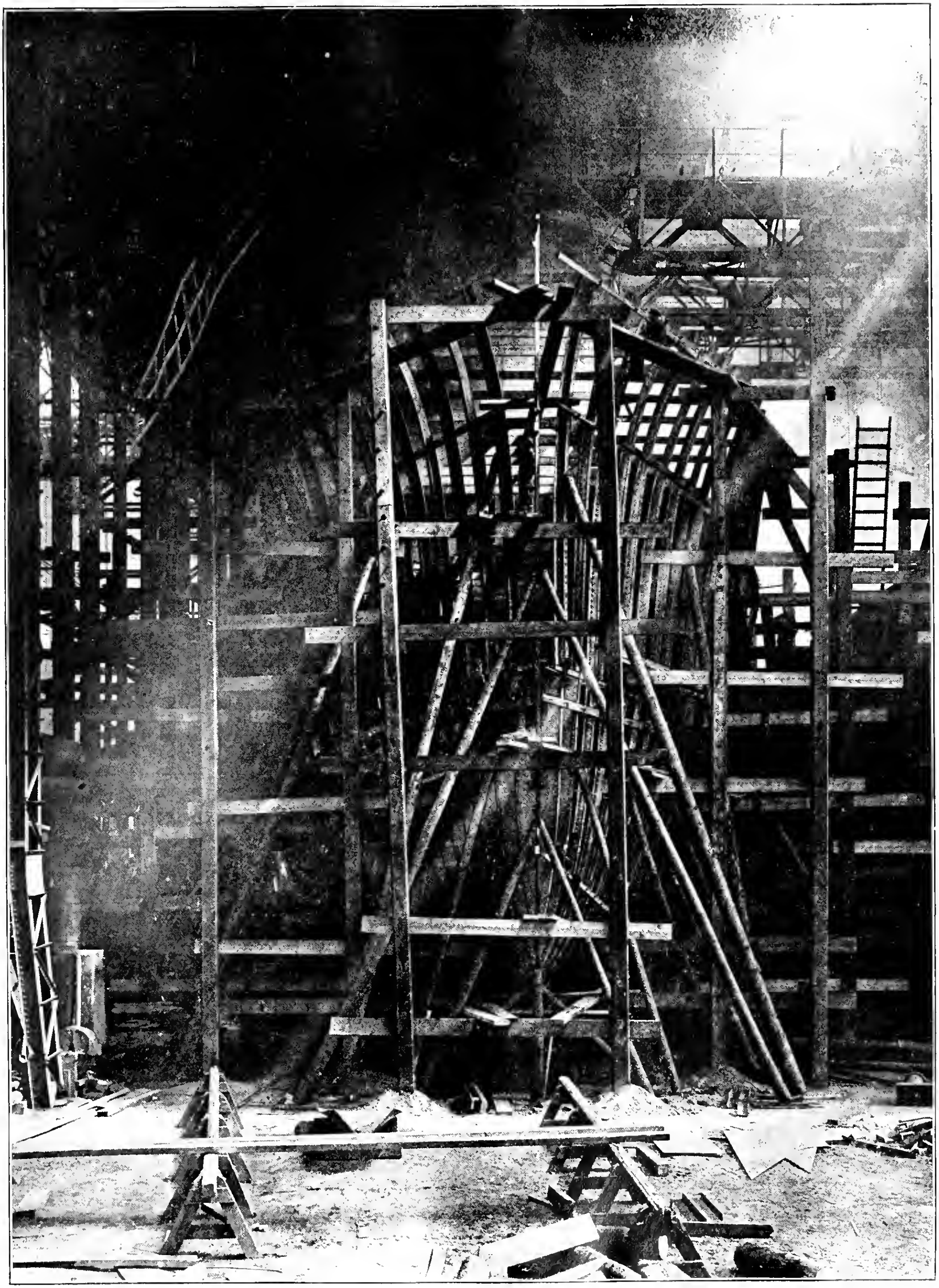


CANADIAN VICKERS.
Plate Number 3 Berth No. 5.

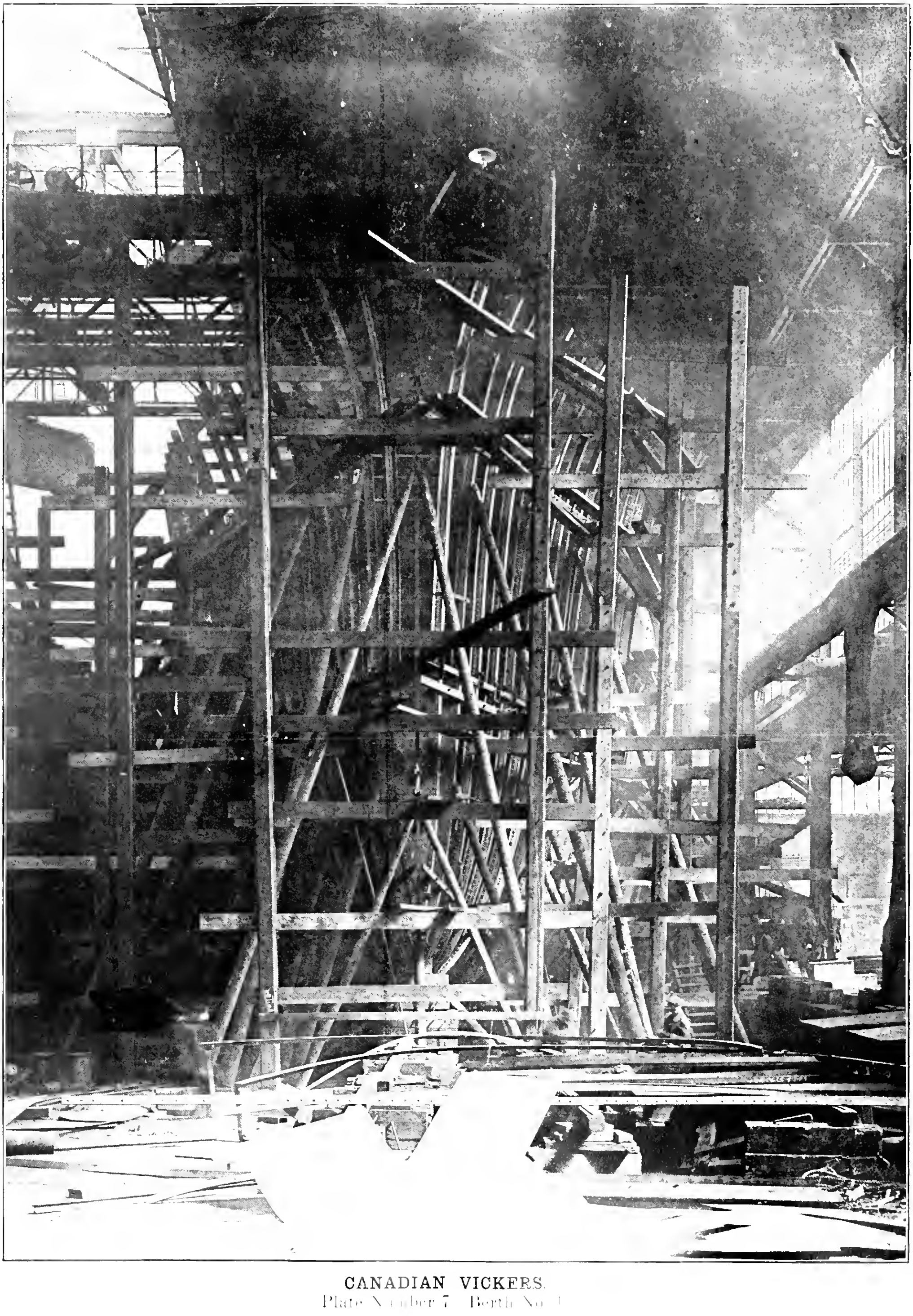
CANADIAN VICKERS.
Plate Number 4 Berth No. 4.



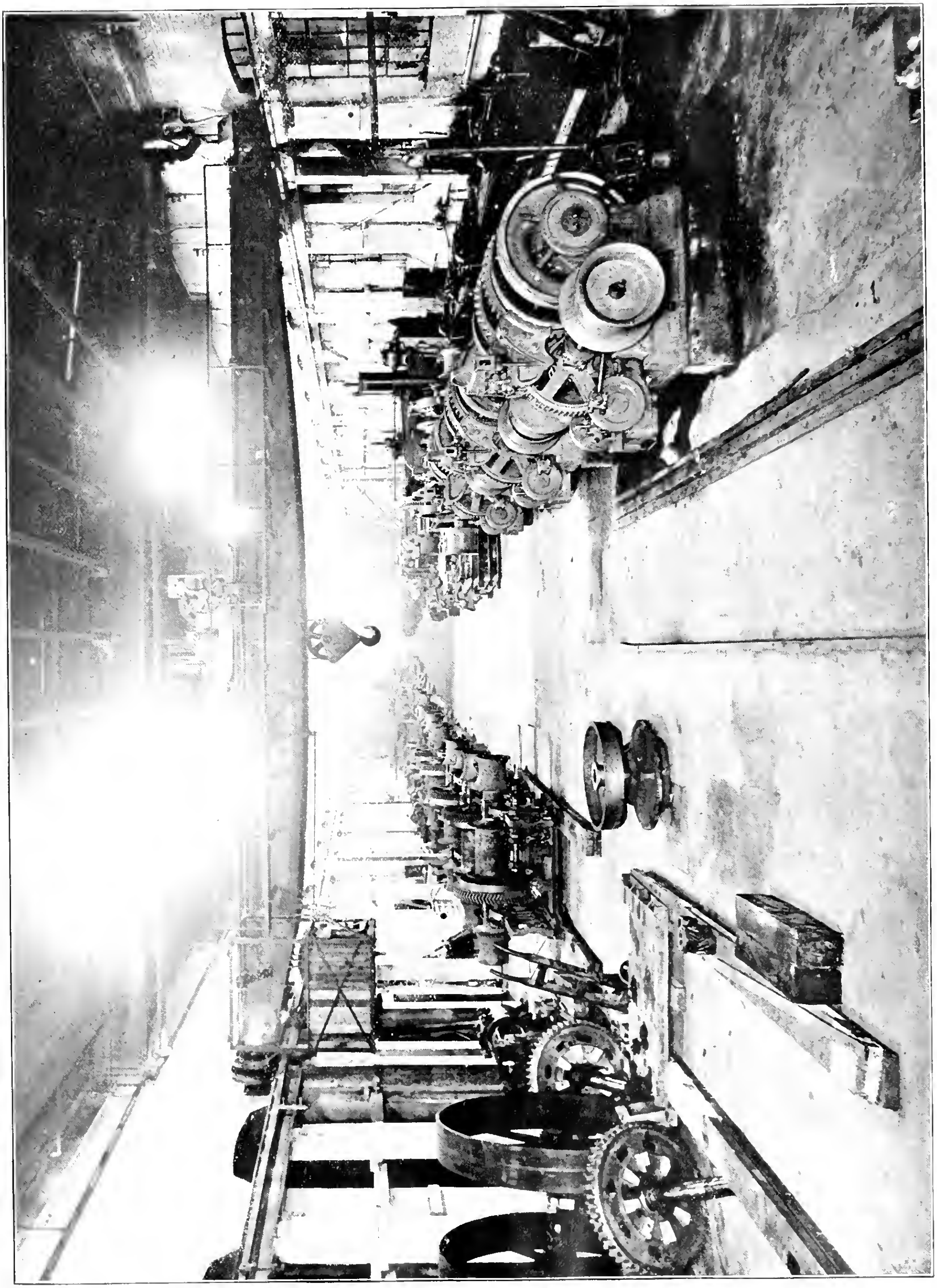
CANADIAN VICKERS.
Plate Number 5—Berth No. 3.



CANADIAN VICKERS
Plate Number 6. Berth No. 2



CANADIAN VICKERS.
Plate Number 7. Berth No. 1



CANADIAN VICKERS.
Plate Number 8. Dock machinery shop.

# The Use of Producer Gas in Metallurgical Industries

By G. PERCY COLE, M.Sc., Technical Engineer, Dominion Glass Company, Ltd., Montreal.

A paper read before the Montreal Metallurgical Association, March 13, 1918.

A gas producer, as you all know, is an apparatus generating a combustible gas by the incomplete combustion of a solid fuel. This is accomplished by forcing a mixture of air and steam through an incandescent bed or stratum of red hot coal. The resulting gas, known commercially as producer gas, is really a mixture of gases, a portion of which, being capable of combining with more oxygen, can be burnt and employed for heating purposes.

The gas producer has always been considered a very simple piece of apparatus; but, just as keeping chickens is a shade more intricate than chucking corn in and taking eggs out, so the satisfactory operation of a producer is not simply dropping in coal and obtaining your gas at a tap.

Strictly speaking, much, and sometimes even most, of the heating effected by solid or liquid fuel is actually performed by the gases given off during the combustion. We speak of gaseous fuel, however, only in those cases where we supply a combustible gas from the outset, such as Natural Gas, or where we produce from ordinary solid or liquid fuel in one place a stream of combustible gas which is burned in another place, more or less distant from the spot where it was generated.

The combustible gases produced by the partial combustion of coal form by far the most important kind of gaseous fuel; and, as the supplies of natural gas are gradually exhausted, will perform an even more important role in the future. Just at this point it is well to distinguish producer gas and other allied gases from the ordinary "illuminating" or "City Gas," made in retorts. When coal is submitted to destructive distillation to produce illuminating or City gas, only a comparatively small proportion of the heating value of the coal (say 1/6 or at most 1/5) is obtained in the shape of gaseous fuel. By far the greater portion remains behind in the form of coke.

I have here a sample of what remains in a bituminous gas producer. You can tell from the appearance of it that there is exceedingly little carbon left in it. If we could burn the fuel in our homes to give an "ash" with as small a percentage of carbon remaining in it, there would have been no occasion for any

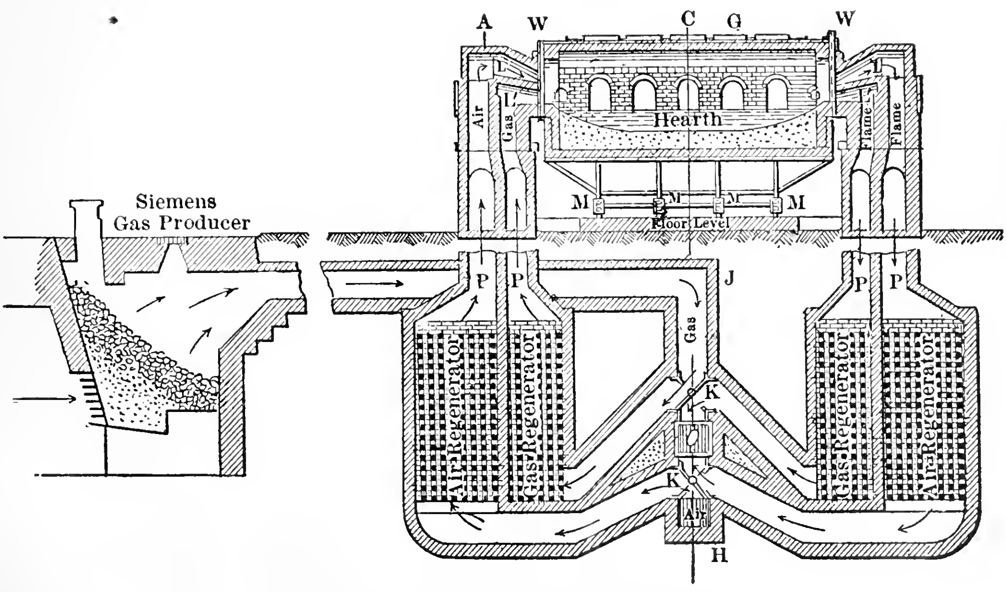



Fig. 1.—Siemens Gas Producer and Regenerative Gas Fired Furnace.—From Fulton's Principles of Metallurgy.

"heatless holidays" this winter. The percentage of fuel lost in the ash is usually around ½ of one per cent. A loss of 2% carbon in the ashes is considered excessive.

To those of you who are not familiar with what a gas producer looks like "in the flesh," Fig. 1 shows the oldest and simplest type, the Siemens gas producer. Another simple form of producer is the iron blast furnace, which is simply nothing else than one type of gas producer. The waste gases from a blast furnace, which have a composition very similar to producer gas, are often utilized for further heating operations, or after cleaning, as a source of power in large gas engines.

The reason why producer gas is used in many metallurgical industries in preference to direct firing with coal is in the long run because it is the cheaper method of utilizing the fuel. It is not possible to make an exact comparison between the cost of firing by producer gas and firing by coal direct, as there are too many varying conditions. In firing direct all the heat leaving the furnace is wasted unless, as in certain special furnaces, it is used to heat the material coming into the furnace, or to raise steam. It is frequently all wasted; in that case the loss depends principally upon the temperature of the furnace. If the temperature is say, 2700°F., then it generally requires twice as much coal to fire direct as to fire by producer gas, because in the latter case we can return two-thirds of the waste heat to the furnace from the regenerators.

A great step in advance was made by the introduction of the Siemens gas-producer and regenerative furnace. We are not here going to enter deeply into the thermochemistry of producer gas, but a few elementary points are absolutely essential to a proper understanding of the subject, and we will touch but briefly on them.

The first principle leading up to the Siemens regenerative furnace is that the fuel can be gasified separately, apart from the furnace, without a high thermal loss. The reason for this is shown in the following equations:

(1) $C + \frac{1}{2}[O_2 + 4N_2] = CO + 2N_2 + 29{,}000$ cals.

(2) $2N_2 + CO + \frac{1}{2}[O_2 + 4N_2] = CO_2 + 4N_2 + 68{,}000$ cals.

When air is passed through a deep layer of glowing carbon the temperature rises, and a gas is produced which consists of one part carbon monoxide and two parts nitrogen (very nearly), and in this stage of the combustion, which involves gasification of the carbon, the number of calories evolved is 29,000 per 12 grams of carbon. If this gas, consisting of carbon monoxide and nitrogen, is afterwards burned with a further supply of air, it gives carbon dioxide and nitrogen, and evolves a further 68,000 calories. The sum of the two heat quantities evolved in the separate reactions (1) and (2) is the same as if carbon is burned completely to carbon dioxide, as shown in this third equation, with a heat evolution of 97,000 calories:

(3) $C + [O_2 + 4N_2] = CO_2 + 4N_2 + 97{,}000$ cals.

You will see that when carbon is gasified, even if heat is entirely lost, more than two-thirds of the total heat of combustion of carbon is still available in the gas, which can be carried to any convenient point and there burned. It is that relation between the heat evolution in the two stages which makes economical gas producer practice possible when air alone is used for the gasification. The first equation represents the main reaction in a producer worked with air; the second represents the combustion in the furnace. The producer gas there shown is a mixture of carbon monoxide and nitrogen containing 33.3 per cent. of combustible gas. In practice, instead of pure carbon, coal is used, and by its preliminary distillation adds to the combustible gases present; the gas for the furnace is therefore richer than is indicated by equation (1), based upon the consumption of pure carbon. With the gas so obtained, it becomes possible to

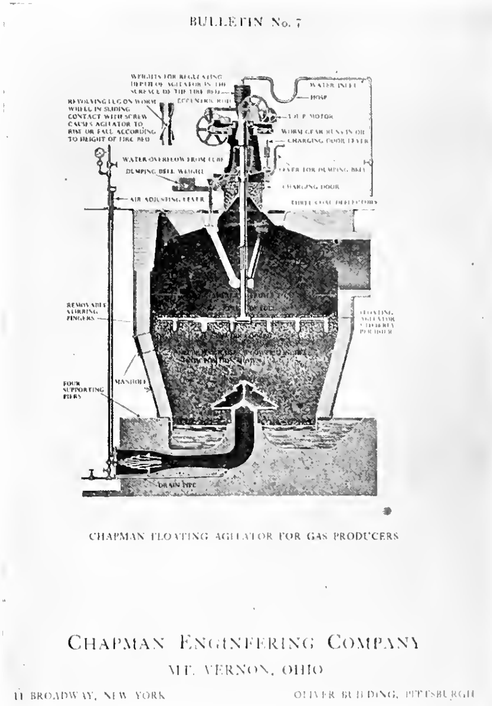



Fig. 2.

construct and work a furnace so that the products of combustion give up a considerable proportion of the heat they contain on leaving the furnace to the air and gas entering.

Fig. 1 showed in section the Siemens producer. It is of the simplest type. The coal is charged from a hopper, falling on a grate, through the bars of which air enters. A deep layer of coal is used; the gasification I have described results, and the gas is taken forward by a flue which conveys it to a furnace or a number of furnaces. In the same figure is shown a furnace of the regenerative type to which the producer gas may be supplied.

The gas passes first up the so-called regenerator, which is packed with chequered brickwork. The air supply for the furnace is allowed to go up another re-

generator similarly packed, and air and gas then pour through ports into the furnace, melting the charge on the hearth. The gas and air after combustion still contain a very large proportion of their heat when they leave the furnace, but this heat is not wasted. The products of combustion divide themselves between a gas regenerator and an air regenerator on the exit side of the furnace. The heat is there given up to the brickwork with which these two are packed, and when the furnace has worked for a considerable length of time, say, twenty minutes, the gases have heated the brickwork and begin to escape hot. To allow that to go further would obviously be uneconomical, and therefore at this stage, by a simple reversing arrangement, the direction of the current is changed, and the gas and air are sent up the two regenerators which now contain a store of heat abstracted from the hot products of combustion. The gas and air therefore enter the furnace hot, they burn over the melting charge as before, and pass through the regenerators by which the air and gas originally entered. These regenerators, cooled by the passage of the cold air and gas, are now heated again by the hot products of combustion, and the furnace is allowed to work in that way until again the gases escaping from it are so hot that if the process were continued it would become uneconomical. In this way, advantages are secured over the working of a direct fired coal furnace. The temperature of combustion is raised because of the higher temperature of gas entering the furnace, and a considerable increase in the thermal economy of furnacing is secured.

In the ordinary arrangement, the Siemens producer is connected through the furnace to a chimney, which causes a draft. The fuel-bed is deep, so that the frictional resistance to the movement of air and gas is high, and consequently working is slow and large producer capacity is essential. Supposing the rate of working is hastened by closing the grate of the producer and blowing in air, a higher rate of working is secured, but it entails drawbacks, which practice soon discovers. The amount of heat generated in the producer, already stated as 29,000 calories for 12 grams of carbon, is, at any rate considerable. With the comparatively large and slow working Siemens producer, that heat can be very largely dissipated, so that the temperature around the ashes does not necessarily rise enough to produce clinkering difficulties, but as soon as an attempt is made to introduce a higher rate of working by blowing in air, the immediate result is the generation of increased quantities of heat, while the loss by radiation, etc., from the producer remains the same. The temperature in the producer therefore rises, and trouble begins with the clinkering of the ash. The remedy to keep down the temperature in the producer is by blowing in steam with the air. When that is done, it is found that the advantage secured is not confined to the prevention of clinkering, and for the following reason. When steam is blown through very hot carbon it is decomposed, with the production of a mixture of carbon monoxide and hydrogen—the so-called water gas—and, what is important for our purpose, the reaction is accompanied by an absorption of heat, as per equation (4).

(4) $C + H_2O = CO + H_2 = 29{,}000$ cals.

This cools the producer. It adds carbon monoxide and hydrogen to the gas, and without dragging in nitrogen at the same time. The total percentage of combustibles in the producer gas is therefore raised, and since there is less nitrogen in the products of combustion when the gas burns in the furnace, the temperature which can be realized is also increased. This is such a fascinating idea that it has naturally been followed as far as possible, but there are limits imposed on the effectiveness of the method by changes in the reactions which take place as soon as the temperature in the fuel bed sinks below a certain point. If more and more steam is used, instead of the carbon being hot enough to give carbon monoxide from interaction with air, it produces an increasing quantity of carbon dioxide, which is useless for combustion; moreover, the temperature being lower, steam does not act on carbon mainly according to the reaction set out in equation (4), giving CO and H, but begins to produce useless $CO_2$, according to the following equation (5):

(5) $C + 2H_2O = CO_2 + 2H_2 - 19{,}000$ cals.

Besides there is the possibility of undecomposed steam going through with the gas, and as this is an inert substance, it has a definite lowering effect upon the temperature available in the furnace afterwards.

Obviously, then, there is a limit to the effective use of steam, and in order to get the best work it is advisable to regulate the amount of steam mixed with the air. Let us see roughly what amount of steam gives the best results. While the amount of steam required will vary somewhat with the kind of fuel used, the purpose to which the gas is applied, the design of producer and the type of furnace in which the gas is burnt, the average weight of steam used will be from 33 to 40% of the weight of the fuel gasified.

Working with a good grade of bituminous gas coal and with an average consumption of steam we would obtain about 63.5 cu. ft. of producer gas from each pound of coal gasified. With the usual value of steam consumption mentioned above we might expect to obtain a gas analysing somewhat as follows:

| | |
|---|---|
| Carbon dioxide | 5 per cent by volume |
| Carbon monoxide | 27 " " " " |
| Hydrogen | 17 " " " " |
| Methane | 3 " " " " |
| Nitrogen | 48 " " " " |

To give you an idea what is actually being accomplished in everyday operation over long periods in some of the largest steel plants in the United States, the following give average analyses:

**Average Analyses of Producer Gas in Two Large Steel Plants.**

| | Plant A. | Plant B. |
|---|---|---|
| Carbon monoxide | 28.7% | 24.4% |
| Hydrogen | 12.0 | 12.0 |
| Methane | 2.7 | 3.1 |
| Other hydrocarbons | 0.9 | 0.6 |
| Carbon dioxide | 3.7 | 5.6 |
| Nitrogen | 52.0 | 53.9 |
| Oxygen | .... | 0.4 |
| | 100.0 | 100.0 |
| B. T. U. per cu. ft. Net or U. S. Steel Standard | 164.0 | 148.0 |
| " Gross at 32°F. | 184.0 | |

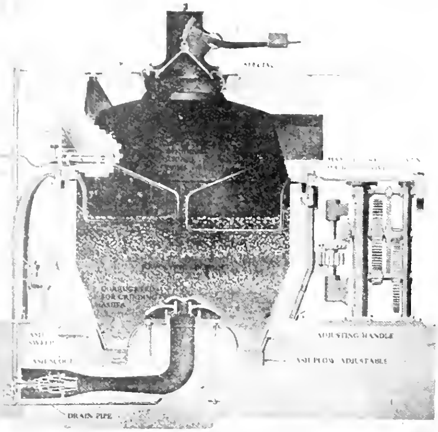


Fig. 3.—Chapman Mechanical Gas Producer with Sticing Tubes.

The combustible constituents of producer gas are mainly carbon monoxide and hydrogen, with small percentages of the hydrocarbons, methane and ethane. While with the old Siemens producer, working with air alone, it was not possible to obtain over 30% of the combustible in the resulting gas, it can be seen from the above that modern producers are capable of giving a gas running from 40 to 50% of combustible. In fact, several manufacturers of producers will guarantee their machines to give a gas that will average not less than 40% of combustibles with a good grade of bituminous run-of-mine or slack coal. Some will also guarantee the calorific value of the gas will not vary more than 10% either way from 155 B.t.u. per cu. ft. when reduced to 62° F. and 30 inches of mercury.

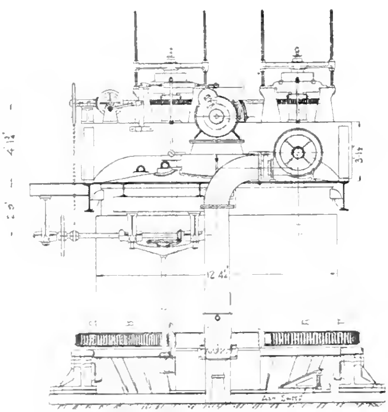
Gas producers have a thermal efficiency of from 80 to 90% based on the gases leaving the producer at a temperature of about 1400° F. A gasification efficiency of 88% is easily maintained continuously in a well-equipped plant.

It is important to recognize that a large proportion of the energy of producer gas lies in its sensible heat, which is all lost if the gas is allowed to get cold before using. In modern practice the sensible heat carried away in the gas represents over 14% of the combustive energy, which is much too large a percentage to lose whenever it can be utilized by using the gas at the temperature at which it is made. This is accomplished by lining the flues with fire brick, and making just as short as possible the distance between the producer and the furnace, where the gas is utilized.

A very satisfactory efficiency is obtained even with flues several hundred feet long so lined with fire brick. A certain length of gas flue will give a chance for the dust, carbon and solid matters to deposit before reaching the furnace; but if the gas flue pipe is a long one and the gases are cooled to such an extent that tar begins to deposit, then your troubles begin in earnest.

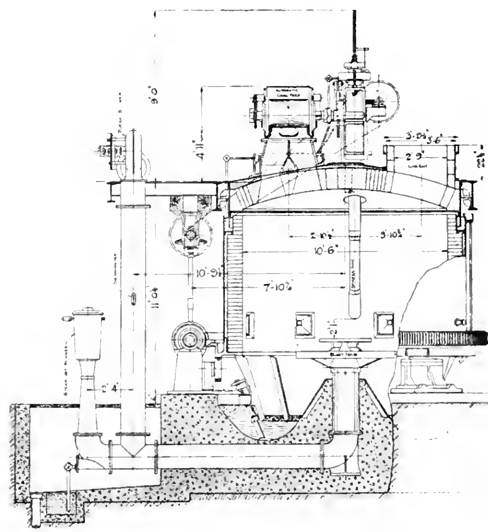
Figures 2 to 6 illustrate several of the most modern types of gas producers, which were described in the lecture.

Those of you who are familiar with the amount of coal burned on the grates in ordinary boilers working



MECHANICALLY STIRRED PRODUCER

Elevation showing both Stirrer Bars



MECHANICALLY STIRRED PRODUCER

Section through Automatic Coal Feed and Gas Outlet

Fig. 4.

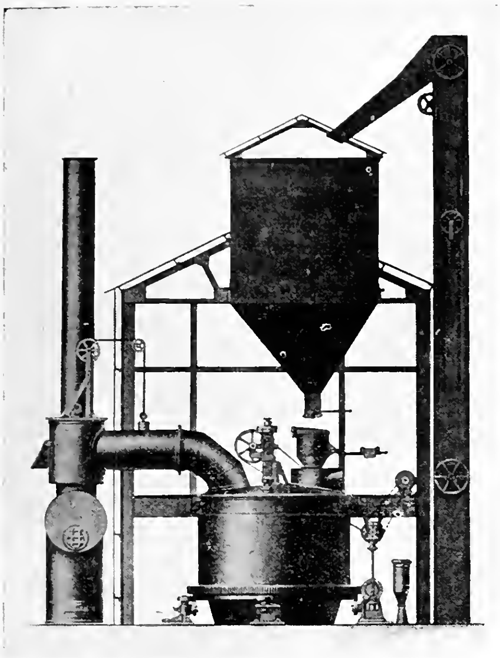


Fig. 5.—General Arrangement of Mechanically Stirred Producer with Drop Feed.

with an excess of air of at least 100 per cent., will know that with natural draft this figure will be from ten to twenty pounds of coal per square foot of grate surface per hour. Only rarely do we have consumptions running up to thirty pounds per square foot of grate surface per hour. It may surprise you to learn what amount of coal can be gasified per square foot of fuel bed in a producer, when you consider it is only the incomplete combustion of coal we are dealing with.

With good coal in a stationary producer and with hand poking, we can gasify from ten to eighteen pounds per square foot of fuel bed area per hour. The upper figure represents the limit of capacity with ordinary hand poking. With modern mechanical producers, however, we can gasify from twenty to forty pounds per square foot per hour, and still deliver a very good grade of gas, high in percentage combustible and calorific values. The amount of coal that you can burn up in a producer is not a measure of its value; it is only when a good quality of gas is combined with a high rate of working that you obtain results that justify the greater expense of the mechanical type.

We will now see what results we can accomplish in metallurgical operations with producer gas.

In the steel industry producer gas is very extensively employed for many operations, and the amount of coal gasified in producers to perform various operations is somewhat as follows:

(a) In continuous heating furnaces for steel billets record runs as low as 122.1 lbs. of coal per gross ton of finished material have been obtained, and it is regularly accomplished below 150 lbs. This record is only about one half of the usual consumption in direct fired furnaces.

(b) In steel melting in regenerative open hearth furnaces using producer gas, a gross ton of cold steel is melted by the expenditure of 600 lbs. of coal. Better records have been obtained, but there are many furnaces where the coal consumption runs up to 800 or 1,000 lbs. In steady work, 500 lbs. coal per ton of steel melted from the cold stock should be sufficient allowance under the best gas producer and furnace conditions. Just recently, some of the manufacturers of equipment for pulverizing coal claim that with powdered coal on open hearth furnaces, good results were obtained, making one ton of steel with 500 lbs. of coal on a 50 ton furnace. Gas firing, however, has so many advantages that it is hardly probable that it will be displaced by powdered coal in the immediate future. Of all the heat supplied to an open hearth furnace, about 25 per cent. is lost in waste chimney gases, and 50 per cent. is dissipated in radiation and conduction, while 25 per cent. is utilized in heating and melting.

(c) In soaking pits heated with producer gas we obtain a coal consumption of 40 to 60 lbs. per ton.

(d) Gas firing is employed for welding and large forging furnaces of all kinds.

In glass melting, using the large regenerative tank

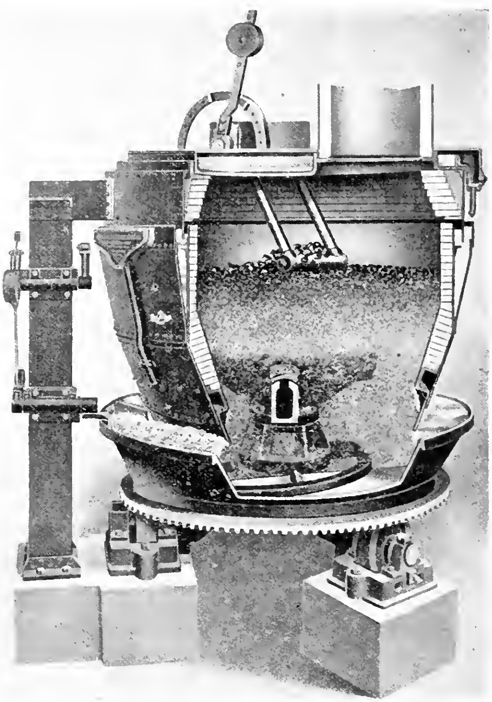


Fig. 6.—Morgan full Mechanical Gas Producer.

furnaces fired by producer gas, one pound of glass is melted by from a half to one pound of coal, which is about half the fuel required by older methods. In the glass industry, the annealing ovens or lehrs are very often fired with producer gas. Lehrs of the "muffle type" can also use this fuel. Practically every glass factory not blessed with a cheap supply of natural gas, is a large user of producer gas.

Producer gas is now also used for roasting metallic ores and for the distillation of zinc, in both of which metallurgical branches much good work has been accomplished.

Furnaces for the manufacture of electric light and battery carbons, and for the manufacture of soda ash, are also fired with advantage by producer gas.

The firing of muffle and melting furnaces used in the manufacture of enamelled ware, also the firing of lime kilns, and brick and pottery kilns, are branches of useful application which have of recent years used producer gas with ultimate profit to these industries.

In short, producer gas can be used advantageously in nearly all large heating and melting operations. Its limitations are that it cannot be carried successfully long distances in small pipes for forges or other very small furnaces.

In localities where it can be obtained at a reasonable price, natural gas is the ideal gaseous fuel to use. Analyses of natural gas from two representative fields are here given. Apart from its high heating value per cubic foot (about seven times that of producer gas) it contains little or no inert nitrogen. You will recall from the analyses of producer gas given above, at least 50% by volume was nitrogen. In melting operations even after regeneration, a considerable quantity of heat is lost in the large volume of hot dead nitrogen gas, which passes into the stack, carrying away heat toward the generation of which it has not contributed in any way. This applies in degree to all gases, rich or poor, burned in air; but the greatest loss is with the poorest gas, and it is for this reason that, for high temperature work especially, it is so important to make the naturally lean producer gas as rich as possible in combustible elements, and thus reduce the volume of nitrogen to be heated per pound of coal burned.

**Analyses of Natural Gas.**

| | West Virginia (U.S.A.) Field. | Tilbury (Western Ontario). Field. |
|---|---|---|
| Methane ($CH_4$) .. .... | 78.22% | *92.2 % |
| Hydro-Carbon .. .. .. .. .. | | |
| Ethane ($C_2H_6$) .. .... | 17.26% | |
| Carbon Dioxide ($CO_2$) .. .. | Trace | 1.4 % |
| Carbon Monoxide ($CO$) .... | ....... | .21% |
| Oxygen ($O$) .. .. .. .. .. | 0.26% | Trace |
| Hydrogen ($H$) .. .. .. .. .. | ....... | 0.40% |
| Nitrogen ($N$) .. .. .. .... | 4.26% | 5.59% |
| Sulphuretted Hydrogen ($H_2S$) | ...... | 0.2 % |
| | 100.00% | 100.00% |
| Calorific Value, per cubic foot .. .. .. .. .. | 1,061.48 B.t.u. | 990 B.t.u. |

*Principally Methane.

Note.—Above analyses were taken at a temperature of 62° Fahr., and a pressure of 14.7 lbs. per sq. inch.

Natural gas is also a very clean fuel to use, whereas raw producer gas, with its sooty and tarry deposits, often makes difficult of accomplishment many special heating operations. At the present time there is really no satisfactory method of cleaning producer gas of soot and tarry matters without cooling the gas and thus losing the sensible heat.

Some modern American producers are fitted with auxiliary equipment for removing the tar. These producers certainly remove the tar and produce a nice clean gas, which in burning looks exactly like natural gas, but the high initial cost of these producers, the difficulty of operating them, and the lower heating power of the gas, render them unsuitable for general use. Where a small quantity of gas is required for special operations, this type of gas producer may find some application, but it certainly does not appear to be an economical proposition in large installations.

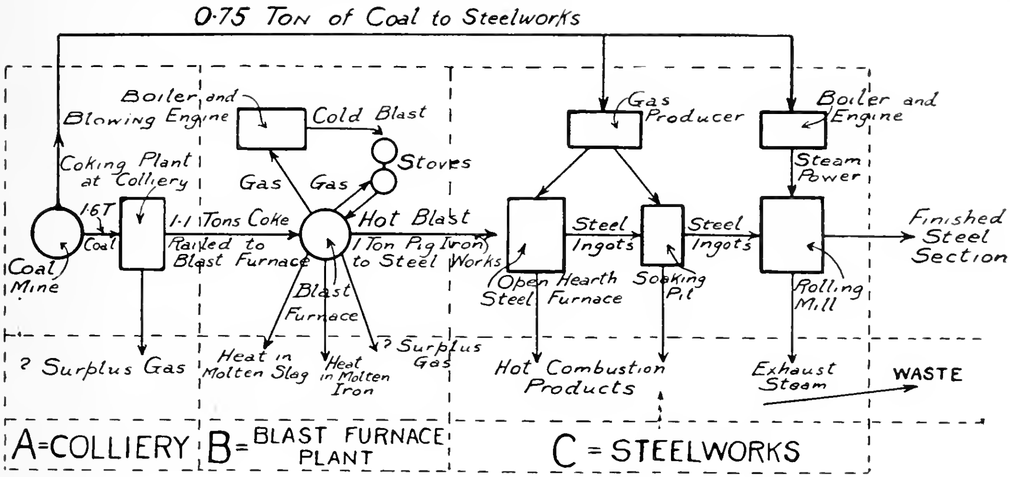
In the above discussion you cannot have failed to notice that no mention whatever has been made of the recovery from the coal of the important by-products such as ammonium sulphate and the tars. It is quite true that our present methods of making producer gas do not give rise to these by-products, in other words, we are not utilizing our coal to the best advantage for the country as a whole, although from a commercial standpoint we may be doing the best possible under the circumstances. The question of fuel economy and the proper utilization of coal is at the present juncture, of the greatest national importance, not only in regard to the actual prosecution of the war, but also in view of the trying years of economic recuperation and re-adjustment that will follow hard upon its termination.

The now well-known scientific methods of utilizing our coal supplies, where all the valuable by-products are saved, offer by far the most promising results of any field of national endeavor. It is tolerably certain that, with an efficient and systematic public supervision and control of fuel consumptions, we ought to be able even with existing appliances, to save many millions of dollars of our annual coal bill; and with improved method and organization, still more millions. The signs of the times are not wanting. In England, the question of the universal adoption of by-product coking ovens, with benzol recovery systems, in the manufacture of metallurgical coke is of such pressing importance that the most up-to-date plants are being installed. The suggestion has been made that public interest would justify the Government fixing by law a reasonable time limit beyond which none of the old wasteful beehive coke oven installations would be allowed to remain in operation, except by express sanction of the State, and then only on special circumstances being proved.

The time may come, very likely in the near future, when we will not even be allowed to operate our present types of gas producers, but will have to adopt producers of the Mond type, which we have not time to discuss in detail here. Although the capital cost of an ammonia recovery gas producer plant of the Mond type is large, it is nevertheless, a most scientific and

economic means of utilizing coal for the production of gas for power and other large scale industrial purposes. Mond gas has a calorific value of about 150 B.T.U. per cu. ft., practically the same as ordinary producer gas, and moreover, it is clean. In England at the present time, there is talk of producing Mond gas at some large centres and distributing it like city gas to groups of industrial establishments. They are actively discussing its application to the glass industry, and so far no inherent quality has been suggested to prevent its use in glass furnaces.

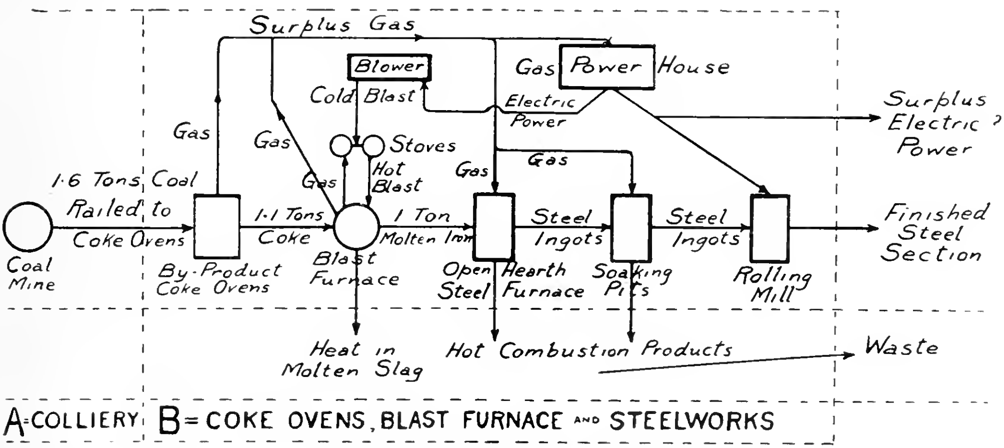
In this connection it is worth mentioning the enterprise of the South Staffordshire Mond Gas Company, who, from their central generating station at Dudley




Total Coal Consumed, 2·35 tons.

PRODUCTION OF FINISHED STEEL ON OLD PLAN

Fig. 7.




Total Coal Consumed 1·6 tons

PRODUCTION OF FINISHED STEEL ON NEW PLAN

Fig. 8.

Port, South Staffordshire, England, were recently distributing Mond gas of a net calorific value of 140 B.T.U. per cu. ft. in mains over an industrial area of 123 square miles, and selling it to consumers at 3½c. per 1,000 cu. ft., which is equivalent to city gas at 14c. per 1,000 cubic feet—a figure that promises well for the future of such schemes in areas of similar industrial concentration.

According to Professor William A. Bone, of the Imperial College of Science and Technology, London, it is altogether likely the steel plants of the future will not require producer gas for their heating requirements, but will be located adjacent to the blast furnaces and by-product coke ovens, and obtain their gas supplies from these sources.

Professor Bone has recently shown (see lectures on "Fuel Economy and the Utilization of Coal," before the Royal Institution of Great Britain, Jan., 1916), that with the concentration of by-product coke ovens, furnaces, steel works, and rolling mills in one plant, coupled with the utilization of the combined surpluses of coke-oven gas and cleaned blast-furnace gas, in large gas engines driving dynamos generating electrical energy for operating the rolling mills, and all other machinery about the plant, producer gas will be displaced as the fuel for the steel furnaces and soaking pits. In this way it has been proved possible to take in iron ore at one end of the works, and turn out finished steel sections at the other, using no more coal than must be charged into the coke-ovens to make the necessary amount of coke for the blast furnaces.

Translated into figures, this means that, whereas formerly, under the old plan, it was necessary to consume altogether at least 2.35 tons of coal per ton of iron converted into finished steel sections, it is now possible, under the new arrangement, to effect the same result with an expenditure of no more than 1.6 tons of coal, or in other words, to effect a net saving of 0.75 ton of coal per ton of iron produced. If this were achieved, it would involve a saving equivalent to about one-third of the 30,000,000 tons of coal annually consumed in British iron and steel works alone at the outbreak of the war. Fig. 7 shows the present methods in the iron and steel industry whereby 2.35 tons of coal are used per ton of steel sections, and Fig. 8 shows Prof. Bones' proposals which accomplish the same result with a consumption of only 1.6 tons of coal.

But even the universal achievement of these new reforms will not exhaust all the possible economies in the production of iron and steel. There will still remain to be dealt with at least one prominent item of present loss—namely, the heat contained in the molten slag running from the blast furnace. This is probably equivalent to between 8 and 12 per cent. of the calorific value of the coke charged into the furnaces, according to the richness and character of the ore smelted The problem of turning this to good account is beset with technical difficulties, but a beginning has been made in at least one British establishment to deal with this problem. However, I am not familiar enough with the steel industry to be able to give you the least inkling as to how this is being accomplished.

# Five Ways of Saving Fuel in Heating Houses

By HENRY KREISINGER.

Technical paper 199, issued by U.S. Bureau of Mines Department of the Interior, 1918.

This country faces a shortage of coal, and it is the patriotic duty of every citizen to save coal in heating his home. About 25,000,000 homes in the United States are to be heated through the winter. If everybody "does his bit," a ton of coal at each home can be saved easily during the winter. For the entire country this saving would amount to 25,000,000 tons of coal, which is nearly as much as all the coal mined in France during the present year. Five ways in which coal can be saved are as follows:

1. Of the coals available in your market select the one that requires the least attention in burning.
2. Use an economical method of burning your coal.
3. Keep your hourse temperature 62° to 65° F. instead of 72° to 75° F.
4. Heat as few rooms as the comfort of your family will permit.
5. Shorten the heating season as much as possible.

**1. Selection of Coals.**

In house-heating equipment the fires can be given very little attention, therefore fuels that require little attention in burning are the most economical and give the best satisfaction. In time of war less desirable coal may have to be used, in order to simplify transportation problems, but the fact remains that some coals are more efficient than others when the same attention is given the fire. Usually the man of the house can attend to the furnace early in the morning and again in the evening. During the day the furnace is left in the care of the housewife or the servant. The housewife has her children, the preparation of meals, and other cares to take up her time, so that she can not give the furnace much attention. In some houses the furnace is attended only when the house becomes either too hot or too cold, and thus the fire is allowed to run from one extreme to the other, conditions which are very unfavorable to saving of fuel. About the same attendance can be expected from a servant.

Therefore, in order that a fuel may be burned economically in a house-heating furnace, the fuel used should be of such kind that the fire requires little attention. The following fuels, in the order named, are the best fuels for house-heating purposes:

Anthracite coal in sizes from ½-inch to egg size.

Gas-retort or metallurgical coke in pieces ½ inch to 3 inches across.

Coal briquets 2 to 3 inches in diameter.

Screened Pocahontas (semibituminous) coal over ¼ inch and through 3 or 4 inch screen.

Sized bituminous coal in pieces ½ to 3 inches across.

If these fuels can be bought, fine sizes or slack coal or other fuels requiring frequent attention when burning should be left for power plants where the firemen can and should give the fires frequent attention.

**2. Use an Economical Method of Burning Your Coal.**

Because of the great variety of fuels used for house-heating purposes, and because of the great variety of house-heating equipment and conditions of operation, only the most general rules can be given for firing the fuel. The details must be determined by actual trial in each furnace.

The conditions under which house-heating apparatus is used are difficult to meet. The temperature of the house is to be kept uniform, with the firings far apart and with little attention given to the fires. The questions for each household to decide are: How much variation in the house temperature can be tolerated, and how much attention can be given to the furnace. The kind of heating apparatus has a great deal to do with the uniformity of the house temperature and the amount of attention that must be given to the fire. Hot-water systems will give much more uniform temperatures with less attention to the fires than hot-air systems. No one set of rules will work satisfactorily in all cases.

### Firing Anthracite.

When firing anthracite, the best results are obtained by spreading the coal evenly over the entire fuel bed. The fire should not be allowed to become too low before putting on a fresh firing. A fuel bed 5 to 10 inches thick gives good results. The fire should be disturbed as little as possible.

### Firing Briquets.

Briquets when properly made are very good fuel for house-heating purposes. However, the supply is decidedly limited. When burning briquets the fuel bed should be kept 8 to 12 inches thick. The fresh charges should be spread evenly over the grate area. The fire must not be disturbed. Poking breaks the briquets and spoils the fire.

### Firing semibituminous Coals.

The semibituminous coals of the Pocahontas type are good fuel for heating a house. They are nearly smokeless and make but little soot. For regular firing, the coal can be spread evenly over the entire fuel bed; or, it can be fired like bituminous coal, the fresh charges being placed alternately on one side of the grate and part of the surface of the fuel bed left uncovered. The alternate method should be used if the firings are heavy. The fire keeps better over night if the last firing is heaped to one side of the grate. Good results are obtained with fires 8 to 10 inches thick.

### Firing Bituminous Coals.

The bituminous, or soft, coals are smoky and cover the flue surfaces with a large amount of soot and tar, which reduces the transfer of heat and impairs the draft. Bituminous coal should be fired by placing the fresh charge on one side of the grate only, leaving part of the surface of the fuel bed uncovered. The volatile matter rising from the freshly fired coal is ignited by the red-hot coal of the uncovered part of the fire and a large part of it burns.

If the entire surface of the fuel bed is covered with a heavy charge, the volatile matter from the fired coal does not ignite for a considerable length of time after firing and passes away unburned as tarry, greenish-yellow smoke. The furnace and the flues become filled with the smoke and when the fire finally works its way through the fresh layer of coal the smoke and the gases may ignite with an explosion violent enough to blow the pipes down and fill the house with smoke. These explosions are particularly apt to happen if the coal contains much slack; therefore, with such coal particular care should be taken that part of the bright fire remains uncovered. This method of firing reduces the amount of soot deposited in the flues so that less frequent cleaning is necessary; it also reduces the heat losses from incomplete combustion, thus directly effecting a saving of coal.

### Draft Regulation.

Draft regulation is perhaps the most important factor in burning coal efficiently in house-heating furnaces. The draft is regulated mainly with the dampers; one of these is on the ash-pit doors, one on the firing door, and one in the pipe connecting the furnace with the chimney. For many furnaces the damper in the flue pipe is an opening covered with a hinged lid A, in figure 1. When this lid is closed the full chimney draft is effective in the furnace. When the lid is lifted, the chimney draws air from the cellar instead of drawing the gases out of the furnace, and the draft in the furnace is reduced almost to nothing. Between the two extremes any draft can be obtained by proper adjustment of the lid.

The damper B on the ash-pit door regulates the flow of air through the fire, and the amount of air flowing through the fire determines the rate of combustion, or the amount of coal that the furnace can burn in an hour. Therefore, to control the rate of combustion and thereby regulate the amount of heat the furnace delivers to the house, the furnace attendant adjusts the damper in the ash-pit door and the damper to the chimney.

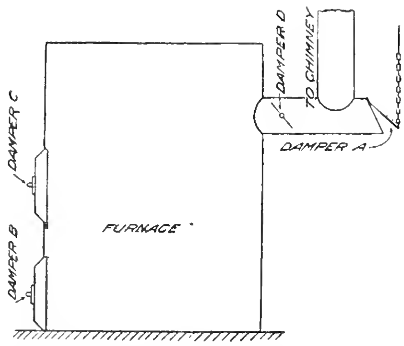



Figure 1.—Position of dampers in a house-heating furnace. Damper A regulates the draft in the furnace and should be used with dampers B and C. Damper B regulates the supply of air through the grate and the rate at which the coal burns. Damper C regulates the supply of air over the fire and the completeness of combustion. Damper D controls the draft and should be used with damper A.

The damper C in the firing door supplies air over the fire needed to burn the gases rising from the fuel bed; therefore, its regulation controls the completeness of combustion of these gases. When soft coal is burned a large volume of combustible gases rises from the fuel bed immediately after the firing; therefore, the damper in the fire door must be opened enough to allow the air necessary for burning the gases to enter the furnace. After the smoky gases cease to rise from the freshly fired coal, the quantity of air supplied over the fuel bed can be reduced by partly closing the damper in the firing door.

There should be a damper, D, in the smoke pipe; this damper can be used in addition to damper A to control the draft.

No rule can be given for the exact adjustment of the dampers. The proper adjustment must be ascertained by trial; with a little care and some patience the proper adjustment of the dampers of any furnace can be determined. In general, to make the fire burn faster, close the lid A (fig. 1) in the pipe leading to the chimney and open the damper B (fig. 1) in the ash-pit door. To make the fire burn slower, raise somewhat the lid in the check draft A, and partly close the damper B in the ash-pit door. The damper C in the firing door is more difficult to adjust because there is no way to determine the completeness of combustion. In burning soft coal this damper should be slightly open all the time. In burning hard coal or coke enough air for complete combustion may enter the furnace through various leaks, even when the damper is completely closed.

### 3. Keeping the House Temperature Lower.

In heating houses considerable fuel can be saved by keeping the temperature in the house 5° to 10° F. lower than is customary; instead of the temperature being between 70° and 74°., it can be kept between 62° and 68° F. without any discomfort or any danger to health. In fact, some medical authorities ascribe the "colds" common in winter to living in too warm houses. Thus Dr. William Brady writes:

Air need never be heated above 65° F. for comfort. Anything above that point represents waste and extravagance. It simply runs up a big coal bill and opens various doors to the coming of the doctor. The onset of cough in winter is almost a sure sign of such extravagance.

Those interested in saving the country's fuel and lowering their own coal bills will be glad to know that keeping the houes at 65° instead of 72° F. means a saving of 15 to 20 per cent. of their fuel. It may also mean a saving on the doctor's bill.

Keeping the house temperature lower is the easiest way to save fuel. It is fuel saved by doing such work. As to the question of health, more sickness is caused by having a house too warm than by keeping it too cold.

### 4. Heating Fewer Rooms.

Another easy saving of fuel can be effected by heating fewer rooms in the house. In many houses the family can get along comfortably by keeping warm three or four rooms instead of heating six or seven rooms. And this can be done without any real hardship on the family. If one stops to think that 55 per cent. of the families in Berlin, Germany, live, sleep, cook, and eat in the same room, living in three or four warm rooms will seem a comfort.* Really only the three rooms in which the family lives need to be heated at all. If consumptives can get well by sleeping outdoors, why could not well people keep well by sleeping in unheated bedrooms with the windows wide open?

### 5. Shortening the Heating Season.

In some homes the furnace is started too early in the fall and is run too late in the spring. The chimneys of these homes are belching smoke and spreading soot over their neighborhood, while the neighbors keep windows and doors open to the outside air and even sit on the front porches. These faint-hearted people in their fear of catching cold heat their houses unnecessarily; thus they waste the country's coal, increase their coal bills, invite sickness into their homes, and make life unpleasant to their neighbors. When mornings and evenings are chilly a grate fire for a short time in one or two rooms will make the house comfortable.

### Conclusion.

Every householder by endeavoring to save coal in the ways suggested can render his country valuable service, and he will not be doing his full duty toward his country unless he renders such service as he can. In addition, he should remember that besides helping his country he will help to shorten the misery and the horror of the great war.

The paper contains a number of references to publications on the utilization of coal and lignite, which we do not reproduce.

* Gerard, J. W., My four years in Germany. 1917.

# Champlain Dry Dock For Quebec Harbour

The present summer should witness the completion of a long needed dry dock for the St. Lawrence River. For a number of years many of the steamers coming to Quebec or Montreal have been too large to enter the Lorne Dry Dock, which was the only provision then made for repairing steamers. The old dock was built between the year 1878 and 1886, and is situated at Lauzon on the Levis side at Quebec. In 1905 the SS. "Bavarian" met with an accident which could have been repaired if an adequate dry dock had been available, but in the absence of this the boat was ultimately scrapped. Large steamers requiring repairs had to be taken either to Halifax or New York.

A new dock was ultimately decided upon, and has been built by the Government; operations were started in May, 1914, and will be finished in July of the present year. The new dry dock is 1,150 feet long, 120 feet wide at the entrance, and 40 feet deep on the sill at high water. It is divided into two compartments by a floating caisson, and the entrance to the dock is closed by a rolling caisson. The dock is well provided with pumps and other facilities, and provides the electrical power necessary for pumping out the water. The completion of this dock will be of immense assistance to the navigation of the St. Lawrence, and should do much to put that system in satisfactory condition.

The dry dock has the following general dimensions. Total length from outer caisson to head wall, 1,150 feet, divided into two compartments. Outer part, 500 feet; Inner part, 650 feet.

| | | |
|---|---|---|
| Width of entrance .................... | 120 | feet. |
| Width at coping ...................... | 144 | " |
| Width on floor ....................... | 105 | " |
| Depth on sill at high water, spring tides | 40 | " |
| Depth on sill at low water, spring tides. | 22 | " |
| Spring tides rise .................... | 18 | " |

| | | |
|---|---|---|
| Coping of side wall above high water, spring tides | 7 | " |
| Floor at outer end below outer sill | $4\frac{1}{2}$ | " |
| Slope of floor transversely | 1 in 100. | |
| Western guide pier | 400 | feet. |
| Eastern guide pier | 500 | " |
| Depth in entrance channel at low tide | 30 | " |

The new dock is located close to the old Lorne dock on the Levis side of the river, a little east of Quebec. It is provided with two guide piers 400 feet and 500 feet long, respectively. The power needed to pump out the dock amounts to over 300 B.H.P., and this will be generated by a steam-electric plant at the dock, although the power will only be needed for about 50 hours during the year, as it would be difficult to get so much power at any time of the day or night from the power companies. The cost of the electric power plant is $240,000, and of the whole dock about $3,365,000.

The works have been carried on by the Department of Public Works with Mr. Eugene D. Lafleur as Chief Engineer,—Mr. V. Valiquet as Superintending Engineer,—Mr. J. K. Laflamme as Resident Engineer,—Mr. S. Fortin, Steel Structural Engineer, has had the approval of plans submitted for the steel structures. The contractors are Messrs. M. P. & J. T. Davis, and Mr. S. Woodard is their Superintending Engineer.

The above particulars are taken from a paper by Mr. U. Valiquet, M.Can. Soc. C.E., Superintending Engineer, Dept. of Public Works, which was read at the Montreal and Ottawa Branches of the Canadian Society of Civil Engineers on April 25th.

## A VENT WAX FOR FOUNDRY USE.

The demand of modern times upon the foundries to furnish castings requiring very intricate core work has made necessary a reliable method of core venting.

Prior to 1908 almost every foundryman remembers the very unsatisfactory methods known and used for venting cores, none of which really did the work in the same manner.

Realizing the demand for a material that would vent the most complicated cores with positive results, and that would standardize core-venting, the United Compound Company at Buffalo, N.Y., in 1908 introduced a wax for this purpose, manufactured by them, and marketed as BUFFALO BRAND VENT WAX.

This wax is made of a proper combination of waxes and oils to produce a hard, pliable wax, which at an ordinary temperature will not stick together. It is pressed into strands of round, flat and oval shapes. The required size and shape is simply bedded in the core when ramming, leading to the proper outlet, and the wax is entirely absorbed by the core, when baking.

BUFFALO BRAND VENT WAX has standardized core-venting. It really improves the core instead of softening it, and it will work satisfactorily with any kind of core binder. Sizes in the rope shape 3|16", and larger are made with or without string in centre. Smaller than 3|16" and all sizes in the flat and oval shape are made without string only.

Buffalo Brand Vent Wax is sold through leading jobbers in Canada, but the company would gladly send samples to any firm requesting same.

## NOTES FROM WINNIPEG.

Mr. L. T. Walls, of the Manitoba Rolling Mills, has contributed to the Expansion Supplement of the Winnipeg Free Press (March 6, 13 and 16), three valuable papers on organization as a basis for Canadian expansion, which we summarize as follows:

The development of a country requires new ideas and causes new responsibilities. The older men built up their businesses on individualistic lines, but the times have changed and co-operation is now an essential condition for success in business operation and development. Western Canada is so strongly materialistic and individualistic that the spirit of co-operation is not easy to attain. Its personal acceptance is difficult because each must realize that others are entitled to participate in the opportunities of a growing trade market. Co-operation, if truly acted on, will result in happier and more congenial conditions in business life.

Business integrity, fair dealing at all costs, and candour between business men, are essential as a basis of successful co-operative industry; while jealousy renders co-operation impossible. Self interest poisons character, but the community idea will develop man's nature as well as aiding the material advancement of the country. Business success depends on organization and men. In Western Canada organization is difficult to attain, but is all the more needed. In business organization the departmental idea is essential. The head of each department has definite duties and responsibilities. The conference or cabinet provides for intelligent co-operation of the departments of a business.

The ideas outlined with regard to a business organization may be applied to the organization of a city or a country. Mr. Walls suggests that the Winnipeg Board of Trade shall make itself truly representative of all trade interests in Winnipeg and district, and shall then call a conference in Winnipeg (as the geographical centre of Canada) of representatives from Boards of Trade in the more important centres of Canada. At this conference would be formed "The Associated Boards of Trade of Canada," and this Association, in co-operation with the Canadian Manufacturers' Association could be recognized by the Dominion Government as the Representative Trade Body of Canada. This organization, co-operating with recognized Farmers' Associations, would be able to strengthen the Government in controlling and organizing the resources of the country for great efforts in war or peace for the production and utilization of necessary products. — From Bulletin of Canadian Mining Institute.

Beals, McCarthy & Rogers, of Buffalo, N.Y., are offering the Canadian trade in their advertisement in another column, a full line of iron and steel hardware, including bars, sheets, angles, beams, etc. They claim the largest stock in New York State, and are prepared to make immediate deliveries. The firm name of the concern was recently changed from Beals & Company to the above, but the firm have behind it the experience and traditions of ninety years' successful business, the original firm having started in 1826. They have at present four modern warehouses in Buffalo, carrying full stocks, and their stores and offices are located at 48-54 Terrace Street.

## HAMILTON AND THE IRON AND STEEL INDUSTRY.

The following diagrams should have formed part of the article with this heading which appeared in our April number. We reprint portions of the article that relate to the illustrations.—Editor.

Hamilton is called "The Birmingham of Canada," and claims to stand in the same relation to the Dominion to-day that Pittsburg does to our neighbors to the south of us. It is the iron and steel industry that has built up Hamilton. Figs. 1, 2 and 3 show the population, assessment and bank clearings, building permits and customs collections. Speaking generally, these curves show the trend of the iron and steel industry in Hamilton.

The 100 iron and steel industries may roughly be divided as follows:

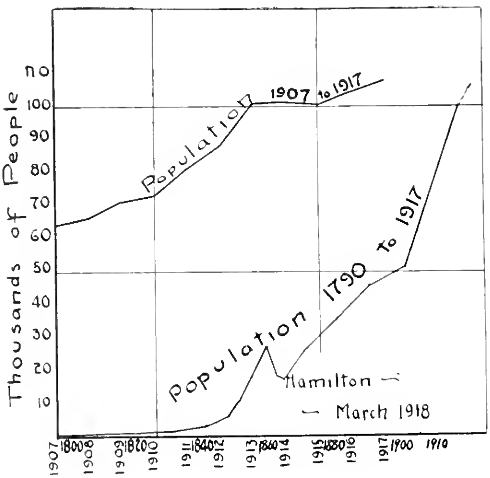



Fig I

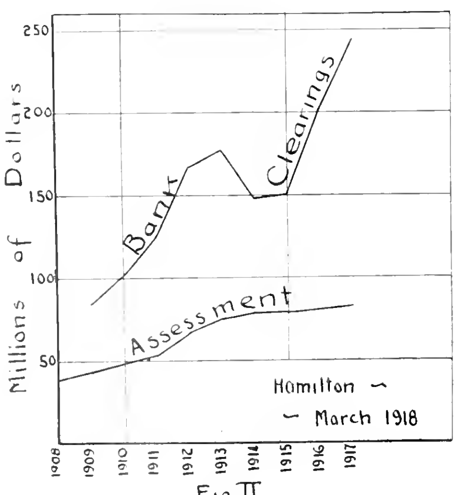



Fig II

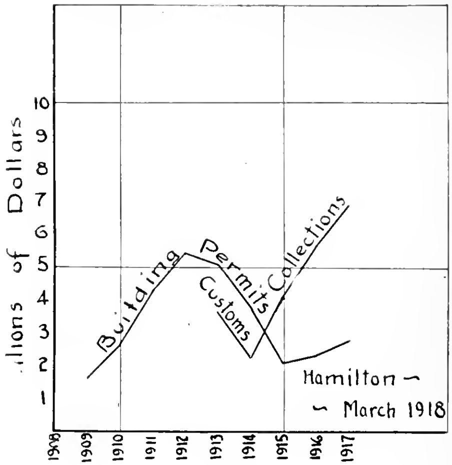
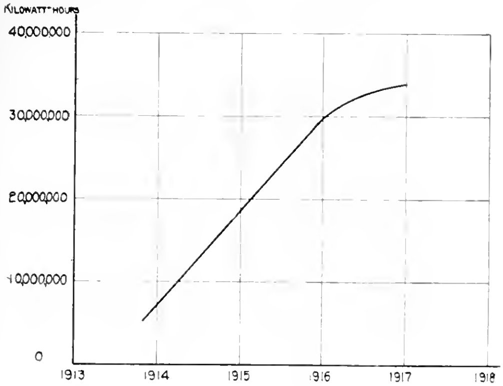



Fig III

| | |
|---|---|
| Basic Iron and Steel Product (not including Iron Foundries), i.e., product from which others are produced | 7 |
| Iron Foundries | 11 |
| Fencing, Wire Goods and Engines | 10 |
| Boilers, Agricultural Implements, Cars, Elevators, Etc. | 17 |
| Hardware and Building supplies | 14 |
| Sundry Metals and Electrical Goods | 17 |
| Tools, Machines, Etc. | 25 |

These divisions are necessarily very rough and arbitrary as many firms cover more than one line indicated above. It must be remembered that among the above are the largest of them employing several thousand men apiece.

Perhaps the next item to consider is electric power and natural gas; the proximity to the Niagara River gives Hamilton exceptionally cheap power rates. For over twenty years the Dominion Power and Transmission Co. has brought power from Decew Falls, a magnificent development with an effective head of 265 feet. This is used for electric powers, manufacturing purposes, house lighting and, until recently, street lighting. The total power supplied to manufacturing industries by the D. P. & T. Co. last year, was about 30,000 K.W.; of this amount 16,000 was used by companies in the steel business alone. About 4,000 was used by companies in the agricultural implement business. Much of the remaining 10,000 was used by the Canadian Westinghouse Co., and similar industries which might really be classed as iron and steel. The Steel Company of Canada is their largest customer. Fig. IV. shows the power used by this company for the last five years. About 1913, the D. P. & T. Co. ran a special high voltage line to the Steel Company, and they exclusively supply electrical power to this immense concern. The Dominion Power and Transmission Co. recently put up a splendid steam generating station to take care of peak loads and bad weather conditions. This has made their service remarkably




Electrical Consumption at Steel Co of Canada Ltd.
Fig IV

good. The fact that this company tapped Niagara Power before it reached Toronto undoubtedly helped to draw manufacturing concerns to this city rather than to our larger neighbor.

Natural gas has been piped to this city for a number of years. It is largely used in heating furnaces, etc., in different manufacturing plants in the city, and also is much valued for domestic use. Unfortunately the demand is considerably above the supply, but in spite

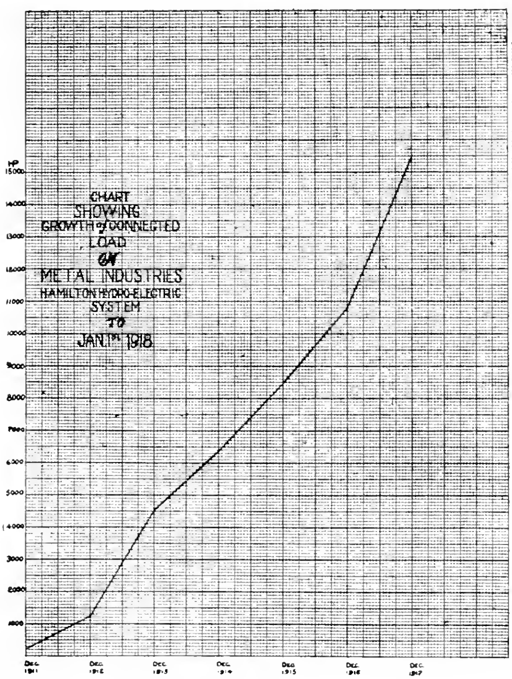



Fig V

of this, it has played its own part in the development of industries in this city.

The last enterprise (though by no means the least) to enter the field of light, heat and power is the Hamilton Hydro Electric Power Development. This is part of the same scheme that provided Hydro Power from Niagara to so many towns and cities in this part of Ontario. Though it is not much over six years since this power came on the market, its growth has been most remarkable. Fig. V. is a curve showing the growth of power connected by the Hamilton Hydro Electric with various metal industries in this city. This growth would have been continued for some years to come if it had not been for the serious shortage which affects this portion of the province, and which will be overcome by the completion of the Chippewa Creek development. Besides the power supplied to metal industries as shown on Fig. V. it must be remembered that many other industries are supplied by the Hamilton Hydro system. All the street lighting is done by them as well as about fifteen thousand homes, which are lighted and generally served by "Hydro."

The Hydro Electric rates are arranged in a very attractive way for the ordinary power consumer and specially so for one who carries a more or less continuous load. As a sample of this we would quote the account of one company having a demand of about 800 K.W., and a connected load of 1,800 K.W. The K.W.H. consumption for 1917 was 3,343,800, and the year's account amounted to $12,639.29, which is an average price of 0.38 cents per K.W.H., though occasionally, if the load factor happened to be specially good, the monthly average rate came to very little over a quarter of a cent per K.W.H.

## MODERN COAL GAS MANUFACTURE.

An interesting lecture on the Initiation, Progress and Development of Coal Gas Manufacture was delivered before the Montreal Branch of the Society of Chemical Industry on the 19th April, by Mr. F. J. Kennedy, superintending engineer of West's Gas Improvement Company. Mr. Kennedy traced the appliances used for distilling coal gas from the simplest retorts, charged and discharged by hand, to the much larger and more perfect apparatus now in use. The first improvement was a machine for charging and discharging by a rake the small horizontal retorts. After that the retorts were made longer and were discharged by a ram as in coke oven practice. A later improvement was the inclination of the retort so that the charging and discharging could be effected more readily, and after this retorts were made vertical, like the Appolt coking oven used in Europe. The latest development, and one with which Mr. Kennedy has been intimately connected, is the continuous vertical retort which is now in use in the LaSalle Plant of the Montreal Light, Heat and Power Company. This retort is not emptied periodically, as was formerly the custom, but the finished and cooled coke is slowly removed by an extractor at the bottom of the retort which is filled up at frequent intervals with fresh coal. In this process, moreover, steam is admitted at the bottom of the retort for the production of water gas which adds itself to the true coal gas produced by distillation. The heat needed for the water gas reaction is largely furnished by the sensible heat of the finished coke which is cooled in this manner before delivery.

The retorts are heated on the regenerative principle by producer gas obtained from a part of the coke. It was interesting to note that the improvements in gas making methods, during the past few years, had nearly doubled the production of gas from a ton of coal. This does not mean that any considerable increase is possible in the amount of gas from the simple distillation of coal, though the more perfect recovery contributes to the result, but by the modern method a part of the coke, formally sold at a low price as a by-product, is now converted into water gas and sold as coal gas, at a more remunerative figure.

A table was presented showing the average products from the distillation of 100 tons of bituminous coal. There were 30 tons of volatile products and 70 tons of non-volatile residue or coke, including 0.10 ton of retort carbon; 22½ tons of the coke was used in the works or was unsaleable "breeze." 47½ tons of the coke was the net saleable product. It was added at this point that a coking plant would produce 60 tons of saleable oven-coke. The 30 tons of volatile products consisted of 16.85 tons or 1,213,000 cubic feet of gas, 7.8 tons or 1,750 gallons of ammoniacal liquor, and 5.35 tons or 1,000 gallons of tar. The gas was purified with the separation of 72 lbs. of carbon bisulphide, 120 lbs. of cyanogen and 1085 lbs. of sulphuretted hydrogen. The cyanogen was used to make 2 cwts. of sodium cyanide and the sulphuretted hydrogen was oxidized to form sulphuric acid which was used, with the ammonia from the ammoniacal liquor, to produce it with a surplus of 0.675 ton of sulphuric acid. The purified gas was then treated for the removal of 225 galls. of "benzol" from which was obtained 100 galls. of benzine and 30 gallons of toluene. The 1000 gallons of tar, previously mentioned, furnished 5 gallons of benzine, 1½ gallons of toluene, 1-3 cwt. carbolic acid, ½ cwt. cresylic acid, 2 1-3 cwt. naphthalene, 2½ cwt. fuel oil, 1-6 cwt. anthracene, and 75 cwt. of pitch, besides residues and losses. The original purified gas amounted to 1,200,000 cu. ft. with a calorific power of 550 B.T.U. per cu. ft. while after the removal of the benzol there remained 1,188,000 cu. ft. of 500 B. T. U. gas; a total loss of 10 per cent. of the heating power.

Mr. Kennedy described the apparatus used in the gas plant for purifying debenzolizing, measuring and storing the gas, but the manufacture of the various chemical by-products is carried out elsewhere. The gas in any large plant must now be debenzolized in order to furnish toluene for munition making.

The lecture was delivered in the Chemistry Building of McGill University and in addition to a large number of lantern slides Mr. Kennedy gave a demonstration of the use and abuse of gas. A series of gas burners were arranged to show what a difference in the amount of light could be obtained from the same gas. Even incandescent burners that were supposed to be all the same would yield very different amounts of light. Wasteful use of gas in cooking was explained and the danger of an explosive mixture of gas and air.

---

Superintendent Bull of the Regina electric department reports a good sale of electric ranges. At the time of the annual exhibition last summer the department inaugurated a special campaign, and since that date about 70 ranges have been installed in residences. — Electrical News.

## BOOK REVIEWS.

The Blast Furnace and the Manufacture of Pig Iron, by Robert Forsythe, 6 x 9 inches, 368 pages. Third edition, 1913. Price $3.00. New York, U. P. C. Book Company.

This was first published in 1907, and since that time it has been the most satisfactory book, dealing with this subject, with which we are acquainted. "The Metallurgy of Iron," by Thomas Turner, published in 1895, deals satisfactorily with the English practice of that time, but it was left for Robert Forsythe to take up American methods of iron smelting.

The book contains: 1, an introductory chapter, describing the commercial classification of iron, the constitution of pig iron and the effects on it of carbon, silicon sulphur, phosphorus, etc. 2. "Materials of Manufacture," describing the ores of iron, their preparation and relative value, blast furnace fuels, anthracite, bituminous coal, coke and charcoal. 3. "Description of Plant," describing the furnace and its construction, the cleaning of furnace gas, hot blast stoves, and blowing engines. 4. "Operation of the Furnace," including blowing in a furnace, handling the products, charging the furnace, operation of stoves, and interruptions in working. 5. "Burdening the furnace," including an account of the nature of slags, calculation of the requirements of ore, fuel, and flux, control of hearth temperature, and the effect on the iron of changes in the furnace conditions. 6. "Action within the Furnace," describing the streams of gases and solids which meet in the furnace, and the reactions by which pig iron is finally produced. 7. "Furnace Irregularities." 8. "Furnace Design and Equipment." 9. "Uses and Grading of Pig Iron." 10. "Principles of Chemistry and Physics."

The book is very well written and will no doubt remain a standard work on this subject for some time, although, unfortunately, it can never be revised by the author, who died in 1907 while the book was being printed. Construction practice changes rapidly, and for this it will be necessary to consult more recent works, which we shall review later.

---

"Steel and its Heat Treatment," by D. K. Bullens, 6 x 9 inches, 429 pages. Second edition, 1918. Price $3.75; John Wiley & Sons, New York.

In referring to this book, we would particularly draw the attention of our readers to the fact that the author has enlarged the subject matter and re-written some portions. The whole cycle of operations from heating for forging to heating and cooling for the final heat-treatment are exhaustively handled, and a mass of information at once useful and easily understood is presented for the readers consideration. Anyone engaged in the practical manipulation of steel will find information in this book relating to every operation connected with the testing of steel; heat generation, heat application, forging; the structure of steel; annealing; hardening; tempering and toughening; case carburizing; case hardening, thermal treatment; carbon steels; nickel steels; chromium steels; chromium nickel steels; vanadum steels; manganese, silicon, tungsten, and molybdenum steels; high speed steels; tool steel and tools; miscellaneous treatments; pyrometers and critical range determinations, and many other matters. The book is illustrated with many figures and a great number of new and original microphotographs, and should be in the hands of all those

interested in the working, heat-treatment and general improvement of steel.

"The Microscopic Examination of Steel," by Professor Henry Fay; 6 x 9 inches, 18 pages letterpress and 29 pages of photographs and micrographs. Price $1.25. John Wiley and Sons, New York.

This book is number 3 of the Wiley Engineering Series, and is based upon investigative work carried out by Professor Fay at the Watertown Arsenal. The general outline of metallographic work and methods is described and many typical examples are taken under review. As would be expected with work carried out at an arsenal, most of the investigations have been made upon gun steel, but this does not detract from the value of many typical results obtained. The book contains a large number of photographs and micrographs, many of the latter being particularly well reproduced. The author deals with the macrostructure and microstructure of steels and the polishing and etching of specimens; he also gives sound advice as to the folly of jumping to conclusions unless based upon wide experience in reading micrographs. A portion of the iron-carbon diagram is given and special mention may be made of micrographs No. 10, of a 1.46% carbon steel; of No. 15, sulphide of manganese; of No. 21, segregation of phosphorus in cold rolled shafting; of No. 33, microstructure of overheated steel; and of No. 44, an island of slag in decarbonized area in 10-inch rifle. Studied in conjunction with some of the standard works on metallography, the reader should obtain valuable assistance from the information contained in this book.

## MONTREAL METALLURGICAL ASSOCIATION.

The annual meeting of the Montreal Metallurgical Association was held on April the 10th, 1918, in the MacDonald Chemistry Building, McGill University. The following were elected as members of the Council for the ensuing year:

Dr. A. Stansfield, Prof. of Metallurgy, McGill University.

Mr. G. Percy Cole, Dominion Glass Co., Limited.

Mr. Charles F. Bristol, Armstrong Whitworth Company.

Mr. Geo. R. Kendall, Peter Lyall Construction Co.

Mr. William C. Lodge, Canadian Inspection and Testing Laboratories.

Mr. H. J. Roast, Jas. Robertson Company.

Prof. J. Haynes, Laval University.

Mr. E. C. Kirkpatrick, Steel Company of Canada.

Mr. W. G. Dauncey, Associate Editor, "Iron and Steel of Canada."

Mr. F. E. Gardiner, Dominion Bridge Company, Lachine.

Mr. B. A. McFarlane, Canadian Allis Chalmers, Limited.

Mr. T. R. Davidson, Thomas Davidson Company.

At the first meeting of the Council held on the 17th of April, Dr. Alfred Stansfield was elected President and Mr. G. Percy Cole, Vice-President.

Details of the activities of the association and application forms for membership may be obtained from the Hon. Secretary, Capt. Jas. G. Ross, 84 St. Antoine street.

## NOVA SCOTIA STEEL AND COKE COMPANY.

At the annual meeting of this company, President Frank H. Crockard referred to the satisfactory condition of the company. The production of steel in their plants had passed through the pioneer stage, it had been shown that they could produce good steel and the development of wider markets would come when normal conditions were re-established. A year ago the plants were almost exclusively occupied with munition orders, but these had been reduced so that during the latter half of 1917 nearly 50 per cent. of their products were for ordinary commercial purposes. It had been estimated that the supplies of coal and ore of this company would last for several hundred years, and that the Wabana ores would probably outlast the iron ores of Lake Superior.

## HAMILTON NOTES.

It is with deep regret that we have to announce the death of Mr. Thos. Partridge, of Burrow, Stewart and Milne Co., Ltd., of this city. On April 12th, after giving a short address in the Emerald St. Methodist Church, of which he was a member, Mr. Partridge suddenly succumbed. For many years he had been in charge of scale work with the above company besides looking after a large part of their other work. Mr. Partridge was considered one of the best scale men in the country and had introduced a number of new features into this industry. He had recently completed the design and construction of some very fine, heavy capacity, track scales for the C. P. R. and C. N. R.

Mr. Partridge had been with the Burrow, Stewart and Milne Co. from the time he was a boy and was held in the highest esteem not only by the office and shop which he was directly connected, but also by a large circle of customers.

Harry M. Marsh, for the past six years Commissioner of Industries and Publicity for the City of Hamilton, resigned that office on April 1st.

C. W. Kirkpatrick, a well known newspaper man, was appointed by the City Council to the position, and assumed his duties on April 15th.

The Hamilton Bridge Works Co., Ltd., has about completed an eight hundred ton order of structural steel for the Coal Preparation Plant for the new coke ovens at the Steel Co. of Canada, Ltd.

The National Steel Car Co. has just completed an order for one thousand box cars for the Dominion Government. These cars will be distributed over a large part of Canada and are stencilled for different railways, the last five hundred being for the Canadian Northern Railway. This order is in addition to the large one mentioned last month.

This company also has under construction the under frames and bodies for twelve electric locomotives for the Hydro Electric Power System of Ontario. The electrical equipment will be installed by the purchasers, we understand these are to be used on the Chippewa Creek Power Development.

A growing industry in this city in a small way is oxy-acetylene welding and cutting. A number of small concerns of this nature have sprung up within the last few years and seem to be doing a thriving business. Some of these firms have full orders book-

ed for some time ahead, and as in this business there is always a certain amount of rush work for repairs, etc., they are kept very busy.

The Dominion Steel Foundry Co. have large new forging orders from the American Government to the value of about $2,500,000.

A new shop about 65 ft. by 320 ft. is being rushed to completion. The Canadian Engineering and Contracting Co., contractors for foundations, have finished the building foundations, a track has been laid through the building for construction purposes and the Hamilton Bridge Works Co., contractors for the building have begun to erect the steel work. Arrangements are being made for a new railway siding to cross Ottawa St. from the G. T. R. Beach Line Spur to serve the new shop.

The foundry has recently booked large orders for locomotive, car and miscellaneous castings and have pretty well sold the output of the establishment for the remainder of the year; only sufficient being reserved for local orders.

Sawyer and Massey Co. report that their shipments of tractors to Regina and the West will reach the limit of their production.

A serious blow to the iron and steel industry in the Hamilton district is indicated by a letter from the Ontario Railway Board to the United Gas and Fuel Co. of this city. The letter states that in order to conserve the supply for domestic use, manufacturers will be prohibited from using natural gas after July 1st of this year.

For some years there has been a serious shortage of gas during the winter months and Tillbury (or Sulphur) gas has been largely used to help out the supply. In February of this year, temporary orders were issued by the Railway Board, but this new order supercedes them and will be enforced pending a Government inquiry into the Natural Gas question.

The majority of the metal working industries in the city will be affected to a greater or less degree. The Steel Co. of Canada, much the largest consumer, expects to substitute oil, and this course will no doubt be followed by many others. The order as it stands at present is rather drastic and an appeal for a modification of the order will shortly be made to the Railway Board. Not only will the metal industries be affected, but it will be quite a blow to the gas companies. During the year 1917 the United Gas and Fuel Company supplied 1,200 million cubic feet to domestic users and 200 million feet to manufacturers, this is not all natural gas but contains an admixture of artificial fuel gas.

---

The Western Power Company of Canada, which on February 1st last took over the property of the Western Canada Power Company, reports an improvement for 1917. The revenue increased from $259,250 to $331,793, a gain of 27.98 per cent. During the year the expenditure was $58,628 on completion of power plant building, installation of equipment, extension to transmission and distribution systems, etc.—Electrical News, May, 1918.

## TECHNICAL EDUCATION AT ALGOMA.

With a view to the establishment of a regular system of technical education for its employees, the Algoma Steel Corporation, through the efforts of Mr. C. H. Speer, Works Engineer, has instituted two classes, one in Electrical Engineering and another in Mechanical Drawing and Machine Design.

These courses are open to any employee of the corporation upon the payment of a nominal fee of one dollar. Arrangements were made with the city for the use of one of the public school buildings for certain evenings in each week, and the ground work for the electrical students has been entrusted to Mr. Walkom, science teacher in the local high school.

At present the proposed system is largely in the experimental stage, and the extent of its future development depends only upon the enthusiasm of the men themselves and the nature of the courses which are most desired and may prove of the greatest benefit to the greatest number.

So far, the success of the movement seems assured, the attendance has been greater than anticipated, and the demands from men in different departments for the institution of courses more in their own line, indicate a feeling of appreciation for the efforts of the corporation in making the opportunity available.

As the work started as an experiment, new problems in the handling of these classes have been cropping out from time to time and considerable patience has no doubt been necessary both on the part of student and teacher, but ways and means have been evolved to cover the ground in such a manner that the student might appreciate the every day application of the theory to practice.

As an instance of one of the difficulties, it was found that a number of the men enrolled were unable to grasp the work outlined below, due to lack of elementary training, so a class was promptly formed to take up arithmetic, algebra, geometry and trigonometry. This class answers two purposes, it leads up to the class in drawing and machine design, and it provides for those men who found the electrical course a little too deep for them; many of them being transferred to this class, with the expressed intention of re-entering the new electrical class in the fall.

While the corporation instituted and supports the movement, its further development is largely in the hands of the men themselves. An educational committee has been formed from among the employees, with Mr. Speer as chairman, and all problems and suggestions are handled through this committee, which makes whatever recommendations it considers advisable.

In connection with the outline of the course in electricity which is given at the end of this article, it was proposed to reach item 8 by the end of June. Beginning at that point in September the course will be carried on under the tutelage of an experienced graduate electrical engineer, thus combining with the theoretical side of the subject as much as possible of a practical nature.

So far the course has been very successful; it is felt to be a step in the right direction, and will no doubt lead up to further courses being opened; for

even now there is considerable agitation among certain of the men for a course in chemistry and metallurgy, with a possibility of classes in English for the foreign element.

While the development of such a movement appeared fairly simple at its inception, it has only succeeded by virtue of great perseverance; but it is felt by those in charge that it was well worth the effort, and to judge from the recommendations of the men's committee, a much broader educational field is bound to be opened up in the near future.

**Courses in Electricity.**

1. Elementary physics, electricity and magnetism.
2. Magnetism and magnetic units.
3. Electro magnetism.
4. Electric units and their derivation.
5. Work and power definitions.
6. Electric circuits and resistance—
   Flow of currents.
   Rheostats.
   Resistors.
   Heater Units.
   Cast iron grids, etc.
7. Magnetic Circuits—
   Properties of various electrical materials.
   Residual magnetism.
   Permeability.
   Solenoids.
   Electro magnets.
8. Armature Winding.
   D. C. and A. C. Machinery.
9. Theory of commutation.
10. Characteristics of Motors and Generators—
    Rating.
    Efficiency.
11. Accessories—
    Controllers.
    Meters.
    Switchboards and apparatus.
12. Electrolysis, Storage Batteries.
13. Operation of Motors and Generators.
    Parallel operation of Generators.
14. Alternating voltages and currents—
    A. C. Apparatus.
    Polar co-ordinates.
    Phase Relations.
    Induction and Capacity.
15. A. C. Generators and their characteristics.
16. A. C. Motors, synchronous and induction.
17. Transformers—
    Design and Operation.
18. Feeders and Transmission Lines—
    Distribution Systems.
    Protective Apparatus.
    Relays, Lightning Arresters, etc.
19. Electric Lighting.
20. Electric Traction.

Necessary instruction in mathematics is given in this course.

---

The Dominion Coal Company Sydney, N.S., contemplate several extensions and improvements to their electrical equipment during the summer months. A central station is to be erected at New Waterford, and from this point transmission lines will be run to the locations requiring current. It is expected that electricity will also replace steam for haulage purposes. —Electrical News, May, 1918.

## NOTES FROM NEW GLASGOW.

The chief topic of interest during the month has been the demand of the local labour unions of the Federation of Labour for recognition by the Nova Scotia Steel & Coal Co., the Eastern Car Co., and other manufacturers in this district.

The Board of Directors of the "Scotia" company considered the question at a meeting held in Montreal on the 15th April, and advised that the management would meet a committee of their workmen to adjust wages or any grievances which the latter might have, or if this arrangement was not satisfactory they agreed to leave the whole question to a Conciliation Board appointed under the Lemieux Act.

It has been stated also that the company has further advised the employees that the management will not discriminate against union members, considering the question of union membership purely a personal matter with the men, but believe that all matters of mutual interest between management and employees can be satisfactorily adjusted by mutuality committees, consisting of representatives appointed by the employees and the company.

This decision was not acceptable to the men, and they called a strike on the 17th April, not only at the Scotia plant, but also in all the other shops in the district.

The following day a message was received from the Department of Labour, to the effect that a Royal Commission would be appointed to investigate conditions, both at Sydney Mines and New Glasgow. The men thereupon returned to work on the 19th.

This commission, consisting of Judge Chisholm, Dr. Forrest, ex-president of Dalhousie University, and Mr. J. B. MacLachlan, secretary of the Amalgamated Mine Workers of Nova Scotia, has now been appointed, and it is expected will open its investigation immediately.

With the exception of the temporary suspension of operations on the 17th and 18th, the Scotia plant has had a steady and heavy production during the past month. A new twenty-four hour record of 640 tons of billets has recently been made on their 28 in. blooming mill.

The various shell finishing plants report good production for the past month.

The Maritime Bridge Co. is said to have a heavy tonnage booked, chiefly structural work in connection with improvements at the Wabana, Newfoundland and Sydney Mines plants of the Nova Scotia Steel & Coal Co., and at the Sydney plant of the Dominion Iron & Steel Co.

The Eastern Car Co. is reported to be making splendid progress on their order of 40-ton box cars for the Canadian Government Railways, and expect to finish their contract during the coming month. They have placed orders for the material for their new order of flat cars and dump cars for the same lines, and will be engaged on this work following the completion of their box car order.

Altogether the prospects are bright for a very busy season in this district and it is to be hoped that the work of the Royal Commission appointed to investigate labour conditions will result in a better understanding between men and employers, thus insuring the maximum production of the various commodities so urgently required at this important stage in our national history.

## CERTAIN HYDRO-ELECTRIC POWER POSSIBILITIES IN THE PROVINCE OF QUEBEC AND ONTARIO, CANADA.

By LOUIS SIMPSON, Ottawa.

A paper presented at the meeting of the American Electrochemical Society, April, 1918.

**Abstract.**

A description of possible hydro-electric power developments of the waters of the Ottawa River, near the city of Ottawa, and of the waters of the St. Lawrence River, near the city of Montreal, Canada.

In these days of hydro-electric power shortage, any information as to possible future development of hydro-electric power must be of interest.

Only of late years has it been recognized that more is required of a hydro-electric power development than the existence of a large minimum supply of water under conditions that will permit its use under a reasonably high head, a fairly low cost of development and a convenient location. It is now recognized that engineering conditions should be such that troubles from ice shall seldom occur and shall at all times be small.

Troubles from ice have during the last few years become a factor of an importance too considerable to be ignored. Hydro-electric powers which, when only partially developed, were comparatively free from troubles caused by ice, have, since their complete development, been subjected to such serious ice troubles as to change the most of apparently low-priced power into one of high price, when the loss caused by closing down was added.

In Canada and in the northern section of the United States there are now to be found but few undeveloped hydro-electric power propositions of magnitude, that when properly developed, and at a reasonable cost, will be comparatively free from ice troubles.

Of such power propositions located in Canada, and reasonably near to the United States, that one situated upon the Ottawa River, 32 miles west of the city of Ottawa, known as The Chats Falls, as probably the best. It is possible, at these falls, to develop between 110,000 and 120,000 E.H.P. The possible head is 50 feet and troubles from ice can be reduced to a minimum. The half of the falls situated in the Province of Ontario, belongs to the Hydro Electric Power Commission of Ontario, the half situated in the Province of Quebec, is owned by several proprietors, but as these are ready to co-operate with the Hydro Electric Commission to secure a joint development, upon terms already arranged, the property is capable of speedy development.

The Canadian Northern Transcontinental Line, now owned by the Canadian Government, passes close by the south end of the falls, whilst very short branch lines could connect the falls with the transcontinental lines of the Canadian Pacific and of the Grand Trunk Railways.

Excellent sites for large works exist at both ends and at the centre of the falls; these can be purchased at reasonable prices.

Another proposition, one of great magnitude and one that, because of its magnitude may not be so quickly made available, is that which is possible, through the construction of a canal from Lake St. Francis to a power house located on the Lake St. Louis, both these lakes being enlargements of the River St. Lawrence.

The possible head will be 80 feet, and it will be possible to develop 1,000,000 H.P.

This development, also, if properly engineered, would be free from ice troubles.

Unfortunately it is not financially possible to undertake this development unless the development be undertaken conjointly with the construction of a deep navigation canal, such a one as will eventually be required to enable the boats that will pass through the New Welland Canal, now in course of construction, to pass from Lake St. Francis to Lake St. Louis. Along with the construction of such a navigation canal, a power canal could be constructed (each interest bearing its fair share of the total cost of the canal). The cost of a joint canal would be very considerably reduced over the cost of two separate canals. Even with such a reduced cost, the construction of such a canal would only be financially possible were a very considerable portion of the total possible power development (from 25 per cent to 50 per cent) to be rented on completion.

One of the hydro-electric power developments using the waters of Lake St. Francis has an historical interest. The first hydro-electric power development operated in Canada was undertaken on one of the discharges from Lake St. Francis at Valleyfield, by the Montreal Cotton Co. This development is particularly interesting, because, in this power house was installed the first direct-connected electric generator ever made. This generator was built by The General Electric Co. at their Schenectady, N.Y., works, upon an agreement with the then general manager of the Montreal Cotton Co. (whose idea it was) that the builders were to be relieved of all technical and financial responsibility. That the installation was a success is evidenced in every modern hydro-electric power house.

From the waters of Lake St. Francis the following hydro and hydro-electric power is developed or else will be developed in the near future. This power is over and above the possible 1,000,000 H.P. already mentioned.

| | H.P. |
|---|---|
| Montreal Cotton Co. .................. | 10,000 |
| Provincial Light, Heat and Power Co.... | 15,000 |
| Cedar Rapids Mfg. and Power Co. ...... | 200,000 |
| Power Development Company ........ | 100,000 |
| Canadian Light and Power Co.......... | 15,000 |
| Total. ........................... | 340,000 |

N.B.—Of this ttotal about 140,000 H.P. is under construction or the construction is to be commenced at an early date.

The immediate district is excellently provided with water navigation and railway facilities. Water navigation connects with Montreal and the sea, to the East, and with Toronto and the Great Lakes to the West.

The railway systems available are the Grand Trunk, the Canadian Pacific and the New York Central.

Land suitable for the erection of works can be purchased at reasonable prices.

With such possibilities of power development in the future the requirements of the users of large blocks of hydro-electric power should not long remain unfilled.

## THE PARKER RUST-PROOFING PROCESS.

An interesting rust-proofing process has been recently developed by the Parker Rust-Proof Company of America, of Detroit.

The effect of the Parker process is essentially a chemical one. The operation consists in taking metal, iron or steel, thoroughly cleaning it by sand blast, pickle, or, in some cases, a soda bath. After this the cleaned metal is immersed in a chemical solution, where it remains a predetermined length of time depending upon the nature of the metal and just what effect is to be obtained. After the metal has been removed from the solution, it is oiled with a special oil. The oil fixes the effect of the immersion and gives it a black mat finish. On articles that are to be painted the oil is not put on, but the metal is left just as it comes from the chemical bath.

According to a patent issued to Walter L. Oeschger and assigned to the Parker Co. (1,254,263, Jan. 22, 1918), the bath consists of a $1\frac{1}{2}$ per cent solution of acid meta-phosphate of tungsten, molybdenum or any of the metals of the third, fourth or fifth groups. (According to G. S. Newth's "Manual of Chemical Analysis.")

The acid meta-phosphate of most general application is made by placing a quantity of iron oxide, preferable black iron scale ($Fe_3O_4$) in a pot with sufficient phosphoric acid to form a soft paste. The iron oxide is preferably powdered in advance. An amount of water equal to the acid is added to keep the mass from caking, after which heat is applied and the material is stirred until a dry granular mass is obtained, which is then powdered. If deserted, heat may be applied to the oxide and acid before water is added. To obtain the phosphates of the other metals, their oxides or carbonates may be similarly treated. The patent states that the bath is preferably kept at the boiling point when the articles are being immersed.

It has been found that the mixing of about 2 per cent of strontium acid meta-phosphate with the iron compound above described gives a much more uniform and harder surface when high carbon steels are treated. Practically the same good result is attained by using the same percentage of molybdenum or tungsten acid meta-phosphates instead of the strontium acid meta-phosphate in combination with the iron compound.

According to another patent (1,254,624, Jan. 22, 1918) issued to the above and also assigned to the Parker Co., the same results may be obtained by first heating the iron or steel articles to about 600 deg. F., and then subjecting them to fumes made by heating the acid meta-phosphates to a sufficient temperature. In this case the articles may be treated right in the furnace.

The tanks used in the wet process are steel with special lining and steam-heating coils attached to the side of the tank. Such an arrangement causes a constant agitation throughout the solution. Experience has taught that the best results are obtainable by a tank built up in this way. Tanks of this type are necessary to rust-proof at a low cost.

The company states that all forms of iron or steel can be processed. The finest kind of dental needles are being treated and in the same tank large structural steel pieces, many parts more than 20 ft. long. Machined parts, castings, pressings, forgings are all handled in a similar way and the effect of the process is likewise similar in all case. Machined parts sometimes do not require cleaning, and they are immersed at once. Smaller parts are pickled or sandblasted in a tumbling barrel, which cuts down the cost of cleaning.

The natural finish resulting from the process is a steel gray, which, when oiled, becomes a soft mat black. The surface of the Parker processed metal is stated to be exceptionally well adapted for enameling, since there is a very fine microscopic etching which helps to bind the enamel. If at any time the enamel should crack and expose a part of the rust-proofed steel, there would be no rusting set in and consequently no peeling off of the enamel.

The rust-proofed metal does not withstand every test imaginable. For instance, it will not withstand acids such as hydrochloric, muriatic, acetic, sulphuric. Again, it will not stand up against constant attack from chemical fumes, although it resists intermittent attacks. It will prevent corrosion when exposed to atmospheric attack and also in a good many cases to other extreme tests where acids are not used. Sterilizing solutions do not affect the process.

The company is operating a plant in Detroit with a capacity of 200 tons of metal a day. Plans are under way for establishing similar plants in New York, Chicago, Philadelphia, Pittsburgh, Boston and St. Louis. Licenses are issued by the company to operate under the process. It is claimed by the company that the process is 90 per cent cheaper than the original method used in England.—Metallurgical and Chemical Engineering.

---

## ELECTRIC FURNACE REDUCES TITANIFEROUS ORES.

Process for manufacturing tool steel from titaniferous iron ores has been patented by E. H. Rothert, president of the Rothert Process Steel C., Seattle. The process pertains both to the smelting of the ore and the subsequent refining of the metal. The company owns two mines, one in British Columbia which is 250 miles from the mill, and the other in the state of Washington which is 150 miles distant. About 400 tons of the ore are to be transported at once from the British Columbia mine by boat. The ore from this reserve analyzes 70 per cent iron and from the Washington mine 60 per cent. It is stated that the sulphur and phosphorus contents in both grades of ores are negligible. For smelting the ore a three-phase electric furnace equipped with three electrodes is used. This furnace has a melting capacity of two tons per 24 hours and is shown in the accompanying illustration together with the control board and auxiliaries. The metal is tapped into a ladle which is suspended in a pit directly under the pouring spout of the furnace. The ladle is hoisted, swung around by a jib crane and is set on a truck which operates on an elevated narrow gauge track. By this means the metal is conveyed to the ingot molds. It then is passed on to the forging department. In the near future the company contemplates extending the melting building 100 feet and installing an additional electric furnace of 10 tons capacity. An 1100-pound steam hammer, of the latest type and design, and a reheating furnace also will be added to the forging department.—Iron Trade Review.

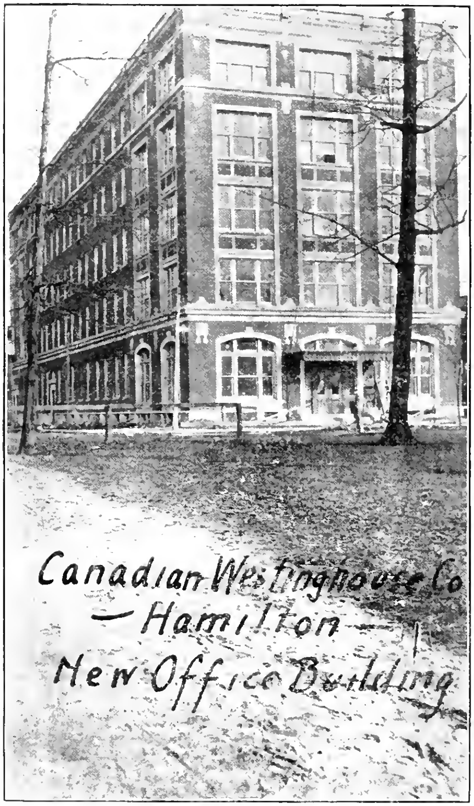
## CANADIAN WESTINGHOUSE COMPANY NEW OFFICE BUILDING IN HAMILTON.

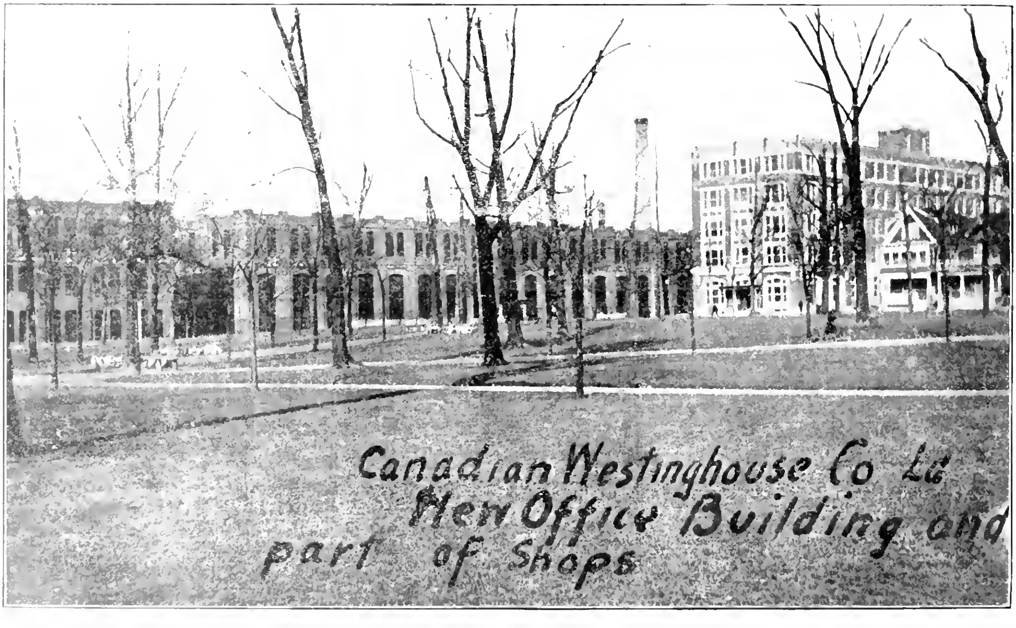
The Canadian Westinghouse Co., Ltd., have almost completed a very fine new office building. Work was commenced on it some ten months ago and it is expected to be ready for the staff to move in very shortly.

The building has five stories and a basement, and is about two hundred feet long by forty-eight wide. It faces on Sanford Ave., Myler Street and Westinghouse Ave., and overlooks a small park.

The first floor accommodates the Purchasing Department, and the Paymaster, and contains a very handsome reception room, while in the rear of the building, with a separate entrance, is a splendid auditorium with a seating capacity of over three hundred. This is completely fitted with a stage, dressing rooms and stereoptical room. The second floor provides magnificent quarters for the President and Vice-President. There is a fine Board Room, and in the rear of the building are the headquarters of the erection department. On the third floor are located the Secretary, the Treasurer, the Accountant, and the Accounting and Cost Departments. The fourth floor provides room for the Sales, Correspondence and Engineering Departments. The fifth floor has a spacious drafting room with a fine blue-print room and tracing vault attached. On this floor are also provided Executive and General dining rooms and kitchens.

The building is a reinforced concrete frame with brick veneer. The halls and wash rooms have terazzo floors with marble borders. The wiring systems in the building are of the latest type and very complete. The heating apparatus is equipped with an air washer and temperature regulating cost. There are two elevators in the building and it is connected to the shops by an



# IRON & STEEL
## OF CANADA

A Monthly Magazine devoted to the Science and Practice of the Iron, Steel, Foundry, Machine and Metal-working Industries, with an up-to-date review of conditions in these and allied industries and trades

ALFRED STANSFIELD, D.Sc., Editor-in-Chief.
W. G. DAUNCEY, M.E., Associate Editor.

The editors cordially invite readers to submit articles of practical interest, which, on publication, will be paid for.

Subscriptions to any address in Canada, the United States and the British Empire, $2.00 yearly. Other countries Postage Extra. Single copies, 25 cents.

Published on the 10th of each month by
THE INDUSTRIAL AND EDUCATIONAL PRESS, LIMITED.
J. J. Harpell, President and Managing Director.

A. S. Christie, Eastern Manager.
H. W. Thompson, Western Manager.

Montreal Office:
35-45 St. Alexander St.
Telephone, Main 2662.

Toronto Office—
C. P. R. Building, cor. King and Yonge Sts.
Telephone, Adelaide 3310.

Changes for advertisements should be in the Publishers' hands ten days before date of issue.

Vol. I. MONTREAL, JUNE, 1918 No 5

EDITORIALS:

Manganese Steel Castings . . . . . . . . 203
The Iron Blast Furnace . . . . . . . . 204
Electric Rolling Mills . . . . . . . . 204
American Iron and Steel Institute . . . . . . . . 204
Montreal Metallurgical Association . . . . . . . . 205
Royal Society of Canada . . . . . . . . 205
The Canadian Patent Office . . . . . . . . 205
American Society of Mechanical Engineers . . . . . . . . 206
Printed Copies of Patents . . . . . . . . 206
Canada Western Steel Co., Ltd . . . . . . . . 207
Foundry Moulding Sands . . . . . . . . 207
New Foundry for Darling Brothers, Ltd . . . . . . . . 207
Notes From Hamilton . . . . . . . . 208
Every American Steel Mill on War Orders . . . . . . . . 208
New Metal Refinery Ready Before Winter . . . . . . . . 208
The Iron Blast Furnace, by W. G. Dauncey . . . . . . . . 209
Huge Sums to Remain in United States . . . . . . . . 212
Book Reviews . . . . . . . . 213
Offer By-Product Fuel . . . . . . . . 213
D. H. McDougall . . . . . . . . 214
W. C. Franz . . . . . . . . 215
The Occurrence and Testing of Foundry Sands . . . 216
Portraits of W. C. Franz and D. H. McDougall. 218-219
"Nicu" Steel and its Manufacture, by G. M. Colvocoresses . . . . . . . . 230
Schwab Confident of Sufficient Ships . . . . . . . . 239

# EDITORIAL

## MANGANESE STEEL CASTINGS.

The inherent difficulties surrounding the manufacture of manganese steel do not seem to be appreciated to their full extent, and one wonders why some of the founders producing this grade of material do not more thoroughly investigate the technical side of the problem. The United States has a capacity of upwards of 70,000 tons per annum and a manganese casting from some of the plants can be relied upon as a standard production. The steel foundry industry has made tremendous strides during the past decade, but the problems of satisfactory production are no less embarrassing than they were ten years ago. There is a perpetual evolution going on and as fast as problems are solved and removed, others arise to confront the manufacturer. These constantly new perplexities are largely due to the enlargement of the field of operations, and call for investigation and an ever progressive policy. The production of manganese steel dates back about 30 years, and the chemical composition of to-day remains practically what it was at the inception of the industry, but the size and weight of individual castings have enormously increased. It was originally considered impossible to satisfactorily produce a piece weighing more than a few hundred pounds, whilst 30,000 lb. castings are now a regular product, and the limit of size does not appear to have been reached. Heat treatment is an essential stage in the production and this controls the thickness of any section, which should not exceed 5½ inches, but by judicious coring, most castings can be made so that no section shall exceed this maximum thickness. At present it is difficult to secure manganese castings from other countries and the time is opportune to develop our own production and by supplying an article possessing the valuable characteristics and of a standard quality to secure the home market against all comers. This market is of greater magnitude than is generally believed, and is capable of almost unlimited extension. The certainty that manganese steel up to 5½ inches in thickness can be satisfactorily produced and scientifically annealed renders it available for the heaviest class of machinery, as well as an infinite variety of other purposes. Given a certain chemical composition, which should approximate to:—

| | | |
|---|---|---|
| Carbon | = | 1.25 per cent |
| Silicon | = | 0.30 " " |
| Manganese | = | 12.50 " " |
| Sulphur | = | under 0.02 " " |
| Phosphorus | = | about 0.08 " " |

and proper equipment for heat treating the production of this class of steel does not present insurmountable difficulties. The manufacture must, however, realize that he has to overcome all the difficulties usually associated with the production of ordinary steel castings plus complications due to the physical and chemical characteristics of this special material. With a correct combination of elements the finished casting will have certain distinctive metallographic and physical qualities, and these should always be utilized to guage the grade of metal before it is allowed to enter into service. In one way manganese steel and cast iron for malleableizing are similar, both must be annealed, and heat treatment is a very essential part of the process, and must be properly manipulated to insure giving satisfactory results. The development of this section of the founders business is only in its infancy and if certain fundamental principles are properly understood and applied there is an unlimited field for future expansion. Grinding takes the place of cutting operations, but even so, ground gears can be produced with a 10-inch width of face and up to 44 inches pitch diameter. By mechanical devices the emery which is constantly dressed to the proper contour of the tooth face, so that when the mating gears are meshed each tooth is provided with a perfect contour on which to roll. This is not the place to study the influence of various chemical elements, nor yet to detail the methods of heat treating and quenching, but it can confidently be asserted that a close following of these points is essential if a satisfactory product is to be the result. Now is the time to establish a standard and a name for manganese castings and the firm getting thoroughly equipped now will find a ready and constantly expanding market available. Manganese steel possesses characteristics not procurable from any other class of steel, and it will be wise to utilize these valuable qualities to the utmost possible extent.

---

We have received a copy of catalogue B from the Hydraulic Machinery Company, Montreal. Included in the contents are presses for many purposes, such as forging shrapnel and high explosive shells, nosing shells, pressing gun-cotton, testing ammunition, etc., etc. Various types and designs of hydraulic pressure pumps, both belt driven and directly connected, are illustrated together with some of the operating mechanism. The firm undertakes the manufacture of hydraulic, knuckle joint and power screw presses for all purposes where pressure is required. Hydraulic pumps, accumulators, valves and fittings and a full line of pulp and paper mill machinery. We are informed that the plant is working to its full capacity, and have orders booked which will keep it going for some considerable time.

## THE IRON BLAST FURNACE.

One of the debts we owed to Germany, before it was Prussianized, was the invention of the blast-furnace and the discovery of cast iron. It would be difficult to find any other appliance which stands so fundamentally at the basis of our modern civilization as the iron blast furnace; in which is produced every year, from the ore, sixty millions of tons of metal, which forms the starting point for all our varied products of iron and steel.

Invented about the year 1400, it has been in use for five hundred years, and in a general way it may be considered to have reached finality in its shape, size and mode of operation. Even now, however, notable improvements are made from time to time, and we must still admit a considerable amount of ignorance with regard to the reactions that take place in this unique appliance. In our March number we printed the first of a series of articles by W. G. Dauncey on the metallurgy of iron and steel. The first article described the ores of iron, while the second, which appears in this number, is an introduction to the study of the iron blast furnace.

## ELECTRIC ROLLING MILLS.

For a long time after the general introduction of electrical power for operating rolls and other machinery in steel plants, an exception was made in the case of the large reversing rolls used for breaking down the steel ingots. This exception was not on account of the amount of power needed, although a large blooming mill may need thousands of horse-power to drive it, but on account of the need of rapid reversing, and of the very great variation in the load. On account of the need for rapid reversing it was impossible to take advantage of the inertia of a fly-wheel to steady the load, and it was necessary to use a non-condensing engine powerful enough to handle the largest load that would have to be met during the passage of the ingot through the rolls.

The Ilgner system of electrical drive overcomes these obstacles in a very ingenious and perfect manner. Two elements are provided, first a motor-generator set provided with a heavy fly-wheel, which revolves rapidly and always in the same direction, thus maintaining a large store of energy for steadying the load, and second a reversing motor for driving the rolls. Electrical connection is made between the motor-generator set and the mill motor so that the energy stored up in the former is always available for use by the latter, and in addition the energy of rotation stored up in the rolls, which was formerly wasted on reversal is by this system returned to the motor-generator.

The Ilgner system was described very fully in a paper on "The Electrical Driving of Winding Engines and Rolling Mills," by C. A. Ablett and H. M. Lyons, presented in 1914 to the Canadian Society of Civil Engineers. We hope to print a paper by E. S. Jeffries on the "Operating Characteristics of an Electric Reversing Rolling Mill," in which is given an account of the Ilgner system as applied to the 34-inch reversing Blooming Mill in the Hamilton Works of the Steel Company of Canada.

## AMERICAN IRON AND STEEL INSTITUTE.

The Fourteenth General Meeting of the Institute was held in New York on the 31st of May under the presidency of Judge Gary, chairman of the U.S. Steel Corporation. The meeting consisted of morning and afternoon sessions for the reading of papers and a banquet in the evening at which eleven hundred sat down in the ball room of the Waldorf-Astoria.

The president, in his opening speech, although depreciating undue optimism, took a hopeful view of the situation in Europe, having regard to the way in which the iron and steel producers were putting all their energy into the business of supplying the Government with the materials needed for carrying on the war. In the past the Government had been suspicious of the motives of the iron and steel men but now, owing largely to the services of the executive committee of the Institute, the Government officials realised that they could depend on the iron and steel producers to aid them in every way possible in this critical time, and in return the iron industry could expect to receive favourable treatment by the Government.

The technical discussions, which occupied the remainder of the morning and the afternoon, were limited to five papers, and most of these were read in abstract. The first subject discussed was "Conservation of Ferro-Manganese," which was considered at length in its various aspects. On the one hand it was shown that the amount of manganese required in specifications could in most cases be cut down by perhaps a tenth of a percent provided the carbon was slightly increased. On the other hand, it was mentioned that 80 per cent ferro manganese should be replaced by lower grade ferros and by spiegel in a number of cases, and that even for very low carbon steel a somewhat lower grade ferro could generally be used. This substitution is important, because American manganese ores are mostly low grade and can be smelted for spiegel or low grade ferros, but not for the standard 80 per cent ferro-manganese.

A paper by J. C. West, Jun., on the Design of the Modern Blast Furnace Stack, was illustrated by lantern slides showing the changes that had taken place in furnace lines during recent years, and a number of important elements in modern furnace construction. The steep bosh and thin walls of the modern furnace were specially discussed.

The most prominent paper in the afternoon was a description of "The Electric Steel Plant at South Chicago." At this plant the so-called Triplex Process is in use. Pig iron is blown in a Bessemer converter, then transferred to a basic open-hearth for the removal of the phosphorus, and finally placed in an electric furnace where the gases and oxides are removed and a particularly high class of steel is obtained. It is claimed that performing a simple operation in each of these furnaces is really simpler than attempting to do them all in one furnace. The feature of this paper was an exhibition of moving pictures showing vividly on the screen the whole sequence of the operations from the time the pig iron was poured into the mixer until the finished steel from the electric furnace was teemed into moulds.

An interesting paper on the "Effect of Phosphorus in Soft Acid and Basic Open Hearth Steels" was pre-

sented by J. S. Unger, who showed in effect that phosphorus in amounts up to 0.13 per cent had merely a strengthening and hardening effect on low carbon steels and that it did not produce brittleness. It was not found even that very low phosphorus steels were any better than those having a moderate amount of that element. Further details of this and other papers will be presented next month.

A paper by B. S. Stevenson on the "Relation of the Trade Papers to the Iron and Steel Industry" gave an account of the increase in usefulness and the consequent increase of status of the trade paper. The trade papers served the industry by compiling statistics promptly and efficiently and also by technical instruction. It was recognised now that a technical or business man must read the trade papers in order to keep up to the times. At one time it was said that the trade paper lived on the industry, but now it was recognised that it lived for the industry.

A paper on "The Modern By-Product Coke Oven and Its By-products," by W. H. Blauvelt, was taken as read.

During the evening, speeches were made by Charles M. Schwab, General Manager of the Emergency Fleet Corporation; J. Leonard Replogie, steel representative on the War Indemniities Board; E. H. Gary and others. The speeches turned in general on the work which had been undertaken in shipbuilding and other requirements of the war, and on the progress which had actually been made. It was impossible to attend the meeting without realizing that although they had been late in taking up the war, the American Government, the American manufacturers, and the American people were now determined to spare no expense and to shirk from no losses that might be necessary to carry the war to a satisfactory ending, and that the Allies who have borne the heat of the day can fight on with confidence, that before long the power of the United States will turn the balance and enable the forces of freedom to win.

## MONTREAL METALLURGICAL ASSOCIATION.

The last regular meeting of the session was held on Wednesday the 15th of May when, owing to too short a notice, a rather small audience heard an interesting paper by M. B. Karr, Metallurgist of the Brown's Copper and Brass Rolling Mills, on the use of the chemical Laboratory to the Brass Rolling Mill. In the unavoidable absence of the author, the paper was read by Mr. H. J. Roast of the James Robertson Company, and led to an interesting discussion. We shall print Mr. Karr's paper in our next number. During the summer the Association will follow its usual custom of visiting some metallurgical works each month. Any who wish to join the Association should send their names to the Secretary, Capt. J. G. Ross, care Milton Hersey Co., Ltd., Montreal, and Dr. Stansfield will be very glad to correspond with any one who may wish to start a similar Association in any other part of Canada.

An interesting article appears in the June number of "Metallurgical and Chemical Engineering" on a Rocking Electric Brass Furnace. The authors, H. W. Gillett and A. E. Rhroads are metallurgists attached to the U. S. Bureau of Mines.

## THE ROYAL SOCIETY OF CANADA.

Founded by His Grace the Duke of Argyll, then Governor-General of Canada, in the year 1882, this society, while young in comparison with the English Royal ociety or the other scientific and literary associations in Great Britain, may be considered well matured in a new country like Canada. The Society represents both Science and Literature, it includes both French and English, and in this respect it plays a valuable part in gathering together these differing interests which are liable in our modern specialized organizations, to lose touch with each other. The Royal Society has a limited membership of about one hundred and fifty, and elects yearly a few of the most eminent men in each branch of literature and science to fill any vacancies that may occur. It is divided into four sections: (1) French Literature, History, Archeology and Sociology; (2) English Literature, History, etc.; (3) Mathematical, Physical and Chemical Sciences; (4) Geological and Biological Sciences. The annual meeting was held in Ottawa from the 21st to the 23rd of May when a large number of valuable papers were read and discussed.

## THE CANADIAN PATENT OFFICE.

We print in this issue part of an address by Sir Robert Hadfield on the subject of Patent Law Reform. In this address he calls attention to the unbusiness-like policy of the Canadian Patent Office in regard to the printing of patents. Those who are interested in such matters know that a printed copy of any United States patent can be obtained for the sum of five cents, while particulars of a Canadian patent can only be gained by having a typewritten copy prepared and the drawings photographed at an average cost of about two dollars. The principle of patenting inventions is to afford the inventor a limited monoply of its use in exchange for making public the method that he employs. The Canadian system renders almost useless for most purposes the information that has been communicated to the Patent Office.

At the present time if information about a Canadian patent is needed, the usual custom is to find what is the corresponding American patent, and to obtain a copy of that. In view of the number of copies of each patent that are needed for the patentee, for the files of the examiners and for exchanges with foreign patent offices, it would appear that little, if any, extra expense would be involved by printing the patents, and the additional service to the public would be gained without serious expense.

At the meeting of the Canadian Branch of the Society of Chemical Industry, recently held in Ottawa, a resolution was passed requesting the Commissioner of Patents to obtain permission to undertake the printing of patents and it is certainly to be hoped that a reform will be made before long, so that at least all new patents will be printed.

## CALLING IN COINAGE.

### Germany Will Substitute Zinc for Nickel.

Germany is calling in her nickel coinage, the metal of which is needed for projectiles, and is substituting zinc for minting coins of this class. Authority has been just given for the minting of ten million marks worth of zinc ten pfennig pieces.

## AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The Annual Meeting of the Ontario Section was held at the Engineers' Club, Toronto, on Monday evening, May 27th. The technical paper for the evening was presented by Mr. J. H. Billings, and dealt with "The Strength of Cast Iron as affected by variations in cross sections." The General Secretary of the A.S.M.E., Mr. Calvin Rice, who had been visiting some of the Society's branches, was present, and delivered an interesting and instructive address.

The results of the election of officers for the Local Executive were as follows:—Chairman, Professor R. W. Angus, Toronto University; Secretary, Mr. C. B. Hamilton, Hamilton Gear and Machine Company. Members of Executive: Mr. James Milne, City Hall, Toronto; Mr. J. H. Billings, University of Toronto; Mr. T. B. Ahara, Canadian Fairbanks-Morse Company.

## PRINTED COPIES OF PATENTS.

Sir Robert Hadfield, President of the Society of British Gas Industries and head of the great firm of Hadfield Limited, Sheffield, in a recent address on Patent Law Reform made the following statement:

"As an example of the ante-diluvian policy of our Empire on this question, an Englishman in this country cannot get a copy of a Canadian Patent without sending to Canada, and even then he gets only a typewritten copy, as patent specifications are not printed there."

This condition of affairs in the Patent Office, Ottawa, is one that demands immediate attention.

The Canadian Patent Office have issued over 180,000 patents and Canada ranks seventh among the countries of the world issuing Patents for Inventions.

A copy of a British Patent costs eight pence, while the U. S. Patent Office sell copies at 5 cents apiece.

A copy of a Canadian Patent costs on an average over two dollars and can only be obtained after considerable delay.

In the U. S. Commissioner of Patents' report to Congress for the year ending December 31st, 1917, the following figures are given relating to this subject.

Printed copies of specifications and drawings of Patents to the number of 2,511,082 were sold at five cents each, bringing to this office on this account \$125,554.10. For 1,277,184 copies sold to libraries the office received \$1,612.50. The total received from the sale of copies of patents was \$127,166.50.

Copies to the number of 1,097,550 were shipped to foreign Governments and 142,640 copies were drawn for office use. The total number of printed copies of Patents distributed during the year was 5,354,136.

These figures show that there is a great demand for printed copies.

The public is interested in the publication of Patents, because it has the right to know the terms of the grant of a monopoly in order to avoid infringement while the monopoly exists, and it has also the right to know what has become public property when that monopoly ceases.

The patentee is interested in the publication of patents as he would readily purchase a number of copies of his patent, to assist him in exploiting his invention.

The Patent Office is urgently in need of printed copies not only to supply the examiners' files, but also to fulfill an agreement with the U. S. Patent Office to exchange copies.

In Great Britain and the United States the libraries in all the great centers contain copies of patents for reference. In Canada it is necessary to go to Ottawa to make a search, and even then the cumbrous typewritten copies, which are not properly classified, make a search difficult and tedious.

The Canadian Patent Act as it now stands provides for the printing of specifications and drawings in Section 63, subject to the approval of the Governor-in-Council.

Undoubtedly, it will take a long time to print the 180,000 patents which have been already issued, but that is a matter for special consideration.

There is no doubt, however, that the system of printing specifications and drawings should be adopted at once, thus preventing the increase of arrears.

Canada has reached such a stage in her development that she should endeavor to be among the progressive nations, particularly in matters that concern her intercourse with other nations. The present time of rapid industrial and technical advance demands a change from old methods which may have been suitable for a young country. The contrast between our methods and those of our neighbour of the South is very striking and great efforts should be made to reorganize our primitive system and bring it up to date.

## MIDVALE TO OPERATE ENORMOUS GUN PLANT.

The Midvale Steel Co. is to build a gigantic plant for the Government. The plant will be erected at a cost of several million dollars, and will be devoted to the manufacture of 16-inch howitzers. The location was not divulged.

The Midvale Steel Co. will receive \$1 a year for operating the Government plant. The Government will furnish all the money for the plants and its equipments, pay all running expenses and salaries. The Midvale Co. will supply its experts and workmen and buy necessary material, etc.

This arrangement is apparently similar to that between the Government and the Steel Corporation. These two big steel units will virtually be in partnership with the United States Government.

The following figures are correct to March 31st 1918, and show the condition of Iron Smelting in the United Kingdom.

| | |
|---|---|
| Toital number of Furnaces built on March 31st 1918 | 498 |
| Total number of Furnaces in Blast on March 31st 1918 | 326 |
| Increase in number of Furnaces in Blast since December 31st 1917 | 11 |
| Furnaces Blown-in since December 31st 1917 | 17 |
| Furnaces Blown-out since December 31st 1917 | 6 |
| Furnaces being built at present time | 12 |
| Furnaces being rebuilt or relined at present time. | 82 |

## CANADA WESTERN STEEL CO., LIMITED.

Western Canada is coming rapidly to the front as a steel producing centre, and the several plants already operating in the West are running to full capacity to supply the local demand, and several are increasing their capacity considerably this season. The Canada Western Steel Co., Limited, of Calgary, Alberta, are putting in an open hearth plant at their mills at Redcliffe. This is a unit plant of 220 tons capacity, and is being erected so that other units may be added in order to make a battery. It is anticipated this plant will be ready for operation very shortly. This company manufactures iron and steel bars 3/8" to 3"; rounds, squares and flats up to 6"; band iron up to 4"; angles and channels up to 2", as well as reinforcing steel and iron bolts and nuts. With the use of natural gas for fuel, which abounds in that locality, they are not at all worried over the fuel situation. The company also control the Alberta Rolling Mills, with plant at Medicne Hat, Alberta. W. H. McLaws is the president, George A. MacKenzie, Managing Director, and A. J. MacWilliams, Secretary-Treasurer.

---

Mr. A. Gordon Spencer, Consulting Chemist and Metallurgist, 619 Transportation Building, Montreal, P.Q., is giving up his consulting practice to devote all his time to the munition and other work of the Peter Lyall & Sons Construction Company, Montreal, as their consulting metallurgist.

---

## FOUNDRY MOULDING SANDS.

In another portion of this issue we publish an important paper on Foundry Moulding Sands. The author, Mr. L. Heber Cole, is to be congratulated upon the very thorough way in which the details of his experiments have been worked out. Natural moulding sands, prepared moulding sands, and synthetic moulding sands are described in separate sections of the paper, and the physical characteristics of an ideal sand are enumerated and explained. The Albany and Brockville sands have been exhaustively experimented with and a series of photo-micrographs prepared to illustrate the results obtained.

The trying out of various sands, as outlined by Mr. Cole, is of the utmost importance to iron and steel founders, and the results must be beneficial, but the man actively engaged in the production of castings rarely has the time to devote to such exhaustive work and looks to some authorities for guidance and information. The whole question of moulding sands and binders is one that might well be taken up for complete study by someone representing the foundry interests and it is certain that ample compensation would be provided for any expenditure that might be involved in such an undertaking. Beyond the selection of a sand, whether natural, prepared, or synthetic, the preparation and functions of binders should be studied. Many of these binders are soluble in water such as molasses, sour beer, distillery refuse, and glutrin. In the same category may be classed corn syrup waste products, such as hydrol, and also glue and silicate of soda. There are three types included in the paste class, flour, starch, and dextrine. Under the colloid class there are clay, magnesia, milk of lime, alumina compounds, and iron compounds, or combinations of these. Under the gum class we have resin, pitch obtained from the distillation of coal in making illuminating gas, pitch from the destructive distillation of wood, and various kinds of asphaltum, or pitches from petroleum products. In the next, or oil class, we have the drying oils, such as linseed and chinawood oil. The iodine number of an oil as taken in the paint trade forms a very good index of its binding properties. There is inexhaustible subject matter for research work, and after standards for sands have been established, and the most suitable binder selected, the problem of reclaiming foundry sand will always demand attention. In localities where the first cost of sand is not high the question of reclaiming used moulding sand is not as important as in other places, still the reclaiming of old sand, and the keeping of sand in actual use in good condition, is of interest to every founder. The heating of moulding sand reduces the bonding power and if sand is heated to 1000 deg. C. and held there for some time complete destruction of the bond will become apparent.

This bonding power of sand is due to the amount of clay contained therein. In determining the bond of moulding sand advantage is taken of the well known fact that clay has the property of absorbing various dyes, the amount absorbed depending upon the quality or plasticity of the clay. Hence, in moulding sand the greater the plasticity and bonding power of the clay present, the larger the amount of dye absorbed. In reclaiming foundry sands, it is essential to restore clay that has been destroyed, and means must be devised not only to replace the percentage of clay, but to get it so intimately mixed that the particles of sand shall all be covered with a film of the clay. By this means the natural bond, or an equivalent substitute for it, may be restored. The importance of this subject immediately becomes apparent when one considers that a more complete understanding of moulding sands would result in better and cleaner castings, in a reduction of moulding and foundry costs, and in a conservation of the natural sand deposits.

---

## NEW FOUNDRY FOR DARLING BROTHERS, LIMITED.

We are informed that Darling Brothers Limited, Head Office, 120 Prince Street, Montreal, are laying the foundations for a modern and well equipped foundry.

This foundry will be situated at the North East corner of Prince and Ottawa, directly opposite their present new plant which is on the South West corner.

It is to be one story concrete building, reinforced, with a frontage of 95'6" by 111', and will contain the very latest contrivances for facilitating the output.

The foundry is expected to be in operation in about ten weeks, when besides handling their own output from the raw material to the finished product, it is their intention to cater to the Trade generally.

It is pleasing to note that in spite of existing conditions, this progressive firm has made three additions to their plant during the War period.

Their slogan is: "Build for the future of Canada. This is the right spirit, and we advocate it now as we have done all along. Get ready for your share of the World's business. Now is the time to act, don't wait until we have beaten Germany, or have any doubts about us doing it. It's a foregone conclusion, therefore, "get busy".

## NOTES FROM HAMILTON.

A serious explosion occurred at the Hamilton Tar and Ammonia Works, Caroline Street North, on April 25th. Three men were killed and a large part of the building was wrecked. At the inquest a verdict was returned in which the company was held responsible for the disaster. It was thought that the tank had a weak splice and it also appeared that it was not equipped with proper gauge.s

The Dominion Steel Foundry have already had to extend the big forge shop that was commenced last month. The building itself will now be 560 ft. long, and a separate building has been erected, nearby, for the power house and hydraulic machinery. The main building will be used for carrying out orders for the American Government. The Hamilton Bridge Works Company has made remarkably good time on the fabrication and erection of the steel for the building, and it is hoped that the new shop will soon be in operation.

The new regulations of the Military Service Act are being felt to quite an extent by the iron and steel trade in this city, but the younger men, who are now being called up, are naturally not so valuable as those who have held responsible positions for a number of years. A few of these more experienced men, who had received temporary exemption on account of their positions, will very shortly have to report for service.

The National Abrasive Co., Biggar Ave., and the D. A. Brebner Abrasive Co., Burlington Street, East, have been having trouble with emery dust, which is discharged from their plants. It is hoped, however, that some new machinery now being installed will remedy the trouble.

The Otis-Fenson Elevator Co. have recently received large orders and are advertising for men in almost every line of work.

Large orders for road making machinery are going out to the townships from Sawyer and Massey Co., Ltd.

The moulders in the Hamilton district are striking for increased wages. The coremakers and moulders walked out nearly a month ago. They are asking for an increase from $4.50 to $6.00 for a nine-hour day. The manufacturers have made a compromise offer, but this has been turned down. Both sides are now waiting for the other to make a further move. About nine shops and 250 men are affected.

## EVERY STEEL MILL IS ON WAR ORDERS.

Every steel mill and finishing shop is working to the limit of its capacity for the Government and the Allied nations. The spirit with which the suggestion from Washington that the shops should devote 100 per cent of their out turn to further the war program of the nation is plain evidence of a grim determination to win and to subordinate everything to this end, regardless of sacrifice.

As one prominent steel man put it recently: "We are pledged to divert our entire product to Government work. No matter what the cost or inconvenience this must be done and will be done. We have a mill and a country. The former would be nothing to us without the latter. So that every ounce of energy we can put into the production of steel will be exerted for the benefit of the nation."

He also remarked that where the occupation of the salesman in the steel trade was not shelved entirely his services were utilized solely to keep customers away with minimum offence to them. No steel orders are now accepted without a statement from the purchaser designating the ultimate consumption, which must coincide with the Government's plans. The out-turn of steel, however, is now so heavy that it is not improbable that there will soon be a surplus after providing for all the varied requirements of the Government.

Some months are likely to elapse, however, before this will be possible, in some instances there will be a curtailment of certain lines to permit of the steel required for them being diverted to more urgent uses, but the balance of manufacture will be preserved so far as possible between all so-related products. Tin plate mills are unusually active in preparing for heavy demands that probably will be made upon them.

The out-turn at present is estimated at 800,000 boxes per week, which is about 95 per cent of maximum capacity. Consumers of plate are well provided for on contracts for the balance of the year. The price to govern after June 30 to be determined by Government agreement.

## NEW METAL REFINERY READY BEFORE WINTER.

The contract for the construction of a nickel and copper refining plant at Deschenes, Que., for the British American Nickel Corporation, calls for completion of the job before the snow falls, T. C. Bate, of the firm of Bate, McMahon and Company, which has the contract, stated last night. The plant will be constructed entirely of concrete. A huge army of employees will be used on the work. The building and machinery will cost over a million dollars.

It is understood that both British and Norwegian interests are back of the scheme. The production of refined metal from the completed plant will be very large and on a scale hitherto unknown in Canada. The company operating the plant has mines in the Sudbury district, where the smelters are located, so that the business between there and Deschens will mean considerable of a melon to the railroads in freight charges on the ore.

Admiral Corresen, a Norwegian, who is head of a large copper refining company in Norway, has interests in the proposed plant, it is understood.

The Ontario Government has been making an effort to have the plant located in this province.

Establishment of the plant marks a forward step in the history of the nickel industry in Canada and incidentally means a nice thing for the railway companies, especially the C.P.R. The plant, which will cost in the neighborhood of a million dollars, will be modern in every respect and its annual production of finished nickel will be large, just how large officials of the company decline to intimate. An almost illimitable supply of power will be obtained from Hydro-Electric energy developed from Rapids on the Ottawa river. Conditions in this respect will result in low operating costs.

Surveys are now being made of a site recently reported purchased from the Hull Electric Company (a C.P.R. subsidiary), and erection of the big plant will begin as soon as the engineers complete their work. The contract for the job has been given the Bate McMahon Company. And Lieut, Col. Robt. Low will be in charge of the work.

# The Iron Blast Furnace

By W. G. DAUNCEY.

In the March issue of "Iron and Steel" was published a paper on Iron Ores, the first of a series on practical metallurgy, in which I dealt with their varieties, characteristics, and the methods adopted to prepare them for smelting in a blast furnace. In this article I propose to show how the modern blast furnace has been evolved, the general principles of its construction, and the way in which it is utilized to produce metallic iron from the ores. Whilst not concerned with the purely historic aspect of early efforts to produce iron, it may be mentioned that the German "Stuckofen" is accepted as the starting point from which the modern blast has developed. Figure 1. illustrates this furnace.

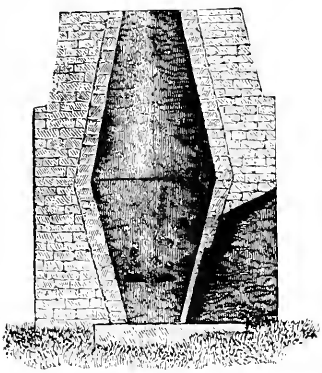


Fig. 1.—"Stuckofen."

Prior to the introduction of this furnace iron was produced in some simple form of open hearth and was reduced directly from the ore, the product being either wrought iron or steel, according to variations in the method of working, but cast iron was not a regular product and its use was unknown. This "Stuckofen" had the shape of two truncated cones joined at their widest diameters, and was built of masonry, with a hearth front so constructed as to be easily taken down so as to remove the resultant bloom of wrought iron. The measurements of such a furnace did not exceed 15 feet in height and 5 feet at the greatest diameter. From this structure the Germans and others evolved blast furnaces of constantly increasing dimensions, always aiming to save fuel and reduce the cost of manufacture. By allowing the metal to become carburised, through remaining in contact with the fuel for a longer period, the product was fluid instead of pasty or solid. This achievement placed what was practically a new metal in the hands of metallurgists, and when once the properties of this iron were understood it became possible to cast pieces of any desired shape and size. Sussex (England) is generally credited with having produced cast iron in about 1350, and there is undoubted proof that it was not later than 1490. The foundry could not claim a monopoly in the use of cast iron. It had been proved that by the purifying influence of fire the metal had been extracted from the ore, and it was fair to assume that another operation under the same influence would remove impurities and yield a malleable iron. This led to the production of wrought iron from cast iron in small fineries, and the blast furnace stepped into the position it has so long held. In studying the various operations incidental to the production of high grade iron and steel one wonders whether it may not be possible, with the rapid advance of chemical and metallurgical knowledge for some of these operations to be eliminated. The production of steel directly from molten pig iron as it leaves the blast furnace illustrates the meaning of the last paragraph. A modern blast furnace, as illustrated by Fig. 2, is practically a steel or iron cylinder of from 90 to 100 feet in height and about 20 feet at its widest diameter, lined with fire-brick and other refractory material.

From the Stuckofen, with its 15 feet of height, to the present furnace of 90 or 100 feet is a long step, but probably the limit of economical working dimensions has now been reached, for it is wiser to have more units

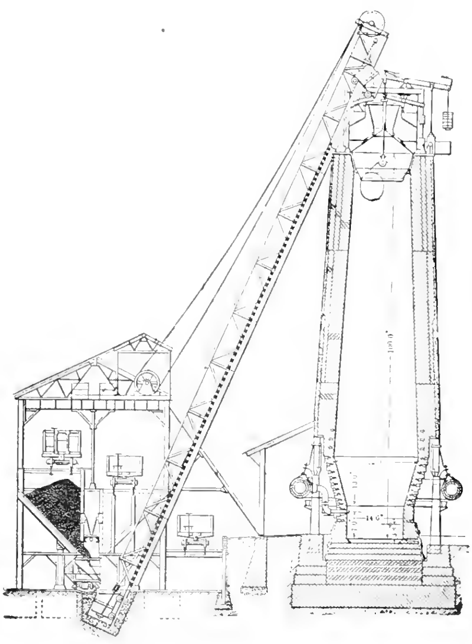


Fig. 2. The Iron Blast Furnace.

instead of greater individual capacity. A furnace of 90 feet by 20 feet producing 600 tons of pig iron per day seems to receive very general approval.

The first blast furnace in America using forced blast was erected and operated in Virginia in 1714, and used the oxidised cap of deposits of cupriferous pyrites, and almost immediately after the Revolution many charcoal furnaces were in operation, whilst in Eastern Pennsylvania anthracite deposits were opened up soon after the introduction of hot blast. The maximum output for an American furnace in 1871 was about 400 tons per week; in 1876 it equalled 560 tons per week; in 1878 it had reached 821 tons, and to-day it is 5,000 tons per week, around which figure it will probably remain. These statements serve to demonstrate the advances made in blast furnace practice during the past fifty or sixty years, and the output of pig iron in America for 1912, 1913, and 1914 reached respectively 29,499,422, 30,736,477, and 23,147,226 long tons, and the approximate consumption of ore was for the same periods, 60,-105,612, 63,399,841, and 43,706,897 tons. In the same three years Canada produced 912,878, 1,015,118, and 705,972 tons of pig iron, which increased in 1916 to 1,-043,978 tons, which equalled 71.5 per cent of the possible capacity of the existing furnaces. In making a study of the blast furnace a division of the subject will probably make explanations easier, and with this object in view we will consider in three sections, first: the construction, then the materials used and the chemical and physical changes brought about during the conversion to metallic iron, and finally the chemical and physical characteristic of the products, and their various uses. A reference to the accompanying diagram (Figure 2) will disclose the internal shape of a blast furnace, and show that the bottom portion is in the form of an inverted frustrum of a cone which connects with the upper conical shaft. Owing to this design, it is necessary to carry the outer walls on a series of iron or masonry columns. From the top the furnace widens out for about four-fifths of its height and then commences to contract where the conical part joins the inverted frustrum, and the latter is called the bosh. In the diagram the line of demarcation is sharp, but it is better practice to join up with a good curve. The previously mentioned columns carry an iron lintel plate on which the upper part of the masonry rests, this being so built as to be quite independent of the lower part. These columns may be 25 feet or even more in height, and the tendency of modern practice is to make them as high as possible. The outer shell is composed of iron or steel plates, and is lined inside with varying thicknesses of refractory material, and is built and lined before the hearth and boshes are put in.

It is upon the hearth and boshes that the highest temperatures and wear will fall so that it is essential that they should be relieved of all pressure except their own weight, and they must also be constructed so that they may be removed and replaced without interfering with the rest of the masonry. On top of the furnace is a charging platform, not shown in the illustration, but large enough to carry all gear necessary for hoists and cup and cone charging apparatus. The latter in a simple form is illustrated by Fig. 3. Many devices have been designed for operating a cup and cone charger, but the principle involved is the same in all cases, the cone must support sufficient stock to practically fill the cup, must be capable of rapid and uniform operation, and must, when released, deliver the charge evenly around the furnace. In another form this charging

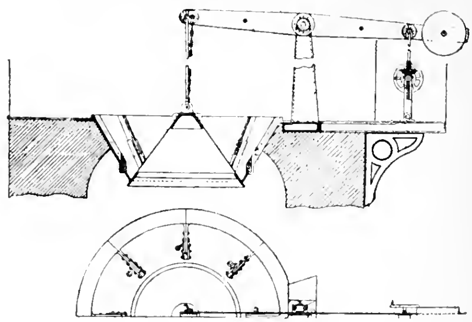


Fig. 3.—Cup and Cone Charger.

apparatus has a central outlet through which gases and products of combustion are allowed to escape on their way to the hot-blast stoves. Fig. 4 shows the arrangement.

It is not possible to lay down any absolute rules regarding the dimensions and form of a furnace for these obviously depend upon the materials to be used and conditions under which operations are carried on. Within limits the higher the furnace the more economically will it work. The advantages of a high furnace are that the gases are more perfectly cooled and escape at a lower temperature, and that the zone in which reduction can take place by carbon monoxide is longer. This

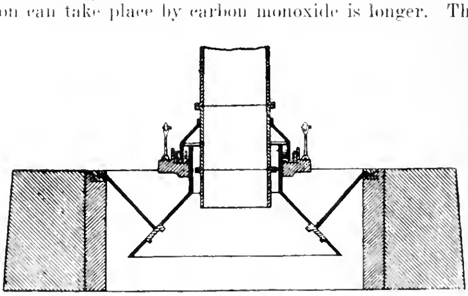


Fig. 4.—Cup and Cone Charger with Gas Outlet.

point will be more fully dealt with when the chemical re-actions come under review. The most advantageous height for a furnace must depend on many conditions, the strength of the materials, the temperature of the blast, and the rate of driving. The height must not be so great that the weight of a column of materials will crush the fuel, for this would seriously interfere with the ascending current of gas, and introduce irregularity in working the furnace. In diameter the width should be somewhere around one-fourth its height. The hearth, in which the molten metal and slag will collect, must be large enough to contain all that can come down between tappings and roughly should be about one-half the width of a furnace at its widest part. Where cup and cone charging is adopted the top limit to which stock may be charged must be from 6 feet to 10 feet below the top of the furnace, and the diameter at this line should be about two-thirds of that at the bosh. The bottom of the cup fixes the charging diameter and may be from 10 to 15 feet in diameter, but its size bears no relation to that of the furnace. After the diameter of various parts have been fixed only one point remains

to be decided before the internal shape can be plotted, this is the angle of the bosh. A flat bosh is to be avoided, because the ascending current of gas may not reach the corners, and unacted on materials may accumulate. On the other hand one that is too steep is also objectionable as the charge is very apt to jam as it comes down. The angle of the bosh, that is the angle of slope with the horizontal, is now generally made about 75 deg. Sharp angles should be avoided, all parts being well rounded off one into the other. It is usual to place about 2 inches of ashes between the metal shell and the inside refractory lining. The greatest care must be taken in constructing the bottom of a blast furnace, as, should molten metal find its way through the bottom, the latter must be able to resist any lifting action. To obtain best results, many plans have been tried out and it will be noted that in Fig. 2 advantage has been taken of the weight of the furnace itself to assist in retaining the bottom in position. Concrete has also been used, consisting of ground fire-brick, ground fire-clay, and ground coke, with the necessary binder. In front of the furnace, passing through the masonry, two openings are left about 12 ins. high and 6 ins. wide, one is at the bottom of the hearth, and the other at the top, and they are not vertically one above the other. The bottom hole is for tapping out the metal, and before the furnace is started it is built up with bricks, leaving a tap-hole about 6 ins. in diameter. The upper hole is for tapping out the slag, and is usually partly bricked up before the commencement of a run. This slag hole is sometimes protected by a water tuyere, and is sometimes only an opening in the masonry. At the top of the hearth the boshes commence, and just where the furnace begins to widen out the tuyers, for the inlet of blast, are placed. Before the development of the present design whereby the main stack is supported upon columns, it was difficult to arrange for more than three arched openings through which to introduce the tuyers. Now, however, owing to the greater clearance around the base of a furnace, the placing and equal spacing of tuyers is an easy matter. Modern practice usually calls for from eight to sixteen tuyers, having an internal diameter of from four to seven inches, and these are placed in "tuyer notches" or openings through the masonry. Both the openings and the tuyers are surrounded by hollow bronze rings, through which cold water is constantly circulating, so as to prevent the melting of the inner ends of the tuyers. These are sometimes made to project—or overhang—into the furnace; it is said that the overhang arrangement gives a more uniform distribution of the air, but it practically decreases the diameter of the hearth. By carrying the zone of combustion inward, it may protect the masonry somewhat, but the ends of the tuyers are liable to damage, and therefore any large overhang is very objectionable. In proportioning the number and size of the tuyers the diameter of the hearth, and volume and pressure of the blast have to be taken into consideration, for the latter must have sufficient velocity to carry it over the whole area of the furnace. A few feet above and near the tuyers are the hottest parts of a furnace, and in order to protect the bosh from this intense heat a number of hollow castings are placed therein and cold water kept constantly circulating through them. In working a furnace certain re-actions take place which cause a deposit of carbon on the inside surface of the brickwork, and this also exerts a protecting influence. There are other methods for protecting the bosh walls, including the use of a plain steel casing over which cold water is continuously running. Whatever method is adopted, the object is to keep the bosh walls cool and thus to minimise the erosive action of the descending stock. To summarize briefly our description of a blast furnace, it is a vertical steel structure, lined with refractory materials, with an inlet at the top for charging materials; with air tuyers around its circumference for the introduction of the necessary blast, and with a tapping hole placed at the bottom of the hearth. Provision is also made for taking off, from near the top, the waste gases and products of combustion. Hot blast stoves for raising the temperature of the blast prior to its admission to the furnace are of infinite variety, size and design, but it will serve our purpose to describe one type, and we will take the Whitwell, as illustrated by Figure 5.

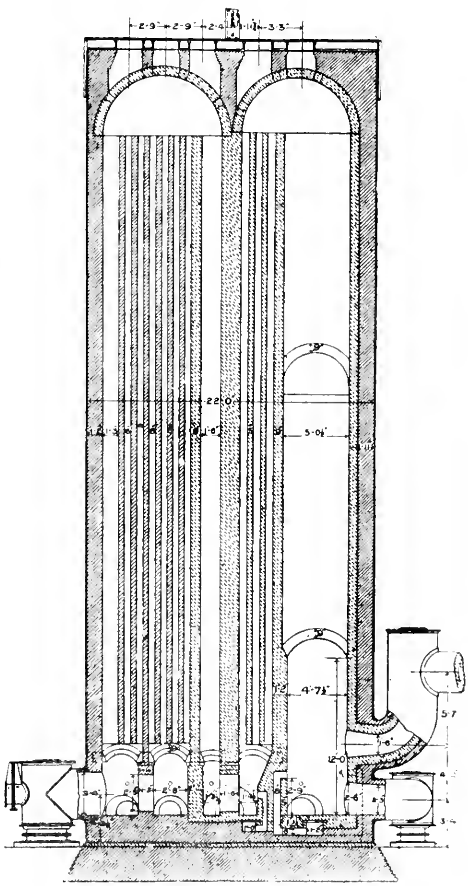


Fig. 5.—Whitwell Hot-Blast Stove.

This is constructed of plates rivetted together to form a cylinder and may be 20 feet in diameter and 80 feet in height, and is lined with firebrick. The heating chamber is divided by firebrick walls, about 5 inches thick, into a series of rectangular spaces or heating tubes. In the earlier models of this stove

these walls were so arranged that the gas had to pass down some tubes, up others, and then down a third set, thus passing three times over heated brickwork; in modern stoves, however, see figure 5, the gas passes once only down through the whole of the tubes. The gas having been brought from the blast furnace by means of the "downcomer" is made to enter the stove in conjunction with sufficient air to support combustion, which takes place in the chamber on the right hand of the figure; from here it travels down the heating tubes and then escapes to the stack at a low temperature. The hot blast stove thus consists essentially of two parts the combustion chamber, and the regenerative or heat storing chamber.

Some blast furnace gases are used in various types of gas engines, but it is not within the scope of this article to describe the latter. Those particularly interested will find a mass of useful information in a series of three papers prepared by Professor H. Hubert K. Reinhardt, and G. Westgarth, and published in the transactions of the Iron and Steel Institute (England, 1906, Vol. III.) When blast furnace gases were first used for power purposes it was realized that freedom from dust and tar would be important, for in early installations considerable wear and tear of cylinders resulted from the quantity of gritty dust carried by the gases. It is also advantageous to use cleaned gas in hot blast stoves as it largely increases their effectiveness if dust is absent. Gases from a blast furnace may be treated in three ways: dry cleaning by means of dust catchers, etc., which do not involve any extra operating cost; further cleaning so as to fit the whole of the gas for use in stoves, boilers, or roasting kilns, etc., and the special cleaning of such part of the gas as is to be used for power purposes. To revert to the hot blast stove (see fig. 5.)

After operating for a given time the brickwork becomes heated, when the valves are reversed and the blast from the engine is driven through the stoves in the opposite direction and in passing over the heated brickwork has its own temperature raised to around 1400 F. This introduction of cold blast to the stove naturally absorbs the heat stored in the brickwork which begins to cool off. When the temperature has fallen to about 1100° F. or 1200° F. the valves are again reversed and fresh gas introduced to re-heat the checkers. The operation is thus one of alternately raising and cooling off the brickwork inside the stove.

The application of hot blast for use in metallurgical operations dates back to 1828 when G. B. Neilson, of Glasgow secured his first patent, and it is not now necessary for us to consider cold air in its application to the blast furnace. To smelt one ton of iron it is necessary to provide from four to six tons of air. This supply is made available through the medium of immense blowing engines of up to 2500 H. P. each, and capable of compressing from 55,000 to 65,000 cubic feet of free air per minute to a pressure of 15 to 30 lbs. per square inch. Between leaving the engines and reaching the furnace the air passes through hot-blast stoves where it is raised to a temperature of between 1200 F. and 1400 F. To understand rightly the advantages of hot blast certain principles must be grasped for at first sight it may appear strange that such heating could effect any economy. In the lower regions of a blast furnace carbon is not oxidized to carbon dioxide ($CO_2$), but only to carbon monoxide (CO). The combustion of carbon by air forced into the blast furnace, therefore, generates 2,473 heat units, while when complete combustion takes place, as in heating the blast, carbon generates 8,080 units. The heat liberated by a unit of carbon burned in heating the blast is thus more than three times as great as that yielded by a unit of carbon burned in the blast furnace. The temperature of combustion near the tuyers naturally increases with the use of hot instead of cold blast, and thus assists in the rapid melting of the slag and iron. This more local combustion, and the smaller quantity of air employed with hot blast, keeps the upper regions of the furnace cooler, and the escaping gases carry off much less sensible heat. The consumption of fuel is decreased owing to the above causes, less flux is needed, and less ash has to be converted into slag. With less fuel less time is needed for its combustion and a furnace of any capacity will contain more ore when hot blast is used, in other words its production will be greater. A very useful table was prepared by C. Cochrane giving the equivalent in cwts. of coke, of the heat brought in by the blast. Generally the sensible heat brought into a blast furnace by the blast is about one-seventh of that required for the smelting operation. It is not necessary to enter into all the data concerning hot blast, but many years ago Sir L. Bell demonstrated that it would not be economical to raise the temperature of blast above 1700° F.

Having dealt with the evolution and construction of a blast furnace, and the design and operation of hot air stoves, it now remains for us to consider the materials used, the re-actions which take place, and the metallic product of the blast furnace, and our next article will be devoted to the consideration of these problems. To those who wish to study the construction, operation, and thermo-chemical re-actions of the blast furnace in detail we recommend the following books: The Blast Furnace and the Manufacture of Pig Iron, by Robert Forsythe; The Metallurgy of Iron, by Thomas Turner; Blast Furnace Construction, by J. E. Johnson, and the Principles, Operation and Products of the Blast Furnace, by J. E. Johnson. Strenuous efforts are being made to gain a more scientific and accurate knowledge of the principles involved in the production of metallic iron by the blast furnace. Three papers were presented at the May meeting of the English Iron and Steel Institute, all bearing upon this subject. Dr. J. E. Stead wrote on Blast-furnace Bears; Mr. T. C. Hutchinson, on Fuel Economy in Blast Furnaces; and Number 2 Committee presented a report on Blast-furnace Practice.

## HUGE SUMS STAY IN UNITTD STATES.

With comparatively few exceptions, all monies advanced to the allies of the United States since the war began have been spent in this country. The treasury simply places the money advanced in banks as the credits are called upon, but has assurance that all of it is expended here for foodstuffs and munitions. The credits advanced to the allies to date aggregate \$5,766,850,000. This includes \$325,000,000 advanced Russia, \$191,000,000 of which still stands to her credit. Obligations of foreign governements purchased to date aggregate \$5,279,750,000, which leaves the excess of loans \$487,100,000 less Russia's \$191,000,000, making the net \$296,100,000, which represents credits advanced but as yet unexpended.—Iron Trade Review.

# Book Reviews

Blast Furnace Construction in America, by J. E. Johnson, jun., 6 x 9 inches, 415 pages. First edition 1917. Price $4.00. McGraw-Hill Book Co., New York. In his preface the author states, "It is surprising that in nearly half a century, since the publication of Sir Lothian Bell's last work, no comprehensive book on this subject has appeared in any language, and a growing need has been felt for one." The first portion of this statement is hardly correct for it ignores Robert Forsythe's book on "The Blast Furnace and the Manufacture of Pig Iron," but we cordially endorse the claim that there was need for such a book. Mr. Johnson deals with his subject under nine headings, which are: I. "Handling Raw Materials"; II. "Filling the Blast Furnace"; III. "The Boiler Plant"; IV. "Blowing Apparatus"; V. "Hot Blast Stoves"; VI. "The Construction of the Blast Furnace Stack"; VII. "Cleaning and Washing the Gas"; VIII. "Handling the Iron and Cinder; IX. "Auxiliaries and General Arrangement of Plants"; X. "The Dry Blast." Each section of the subject is examined in detail and profusely illustrated. The book is supposed to deal only with furnace construction, but as inevitably happens in such cases the principles of construction are overlapped in places by excursions into the theories upon which the smelting of iron has been based. In Chapter III. details of boilers, fuels, cleaning apparatus, and gas burners receive more attention that is usual in books of this type. The information is, however, clearly expressed and shows how modern developments constantly demand greater power and better utilization of the gases and products of combustion from the blast furnace. To the unitiated, to the student, and to the plant manager this book will prove of the utmost interest and assistance.

---

The Principles, Operation, and Products of the Blast Furnace, by J. E. Johnson, jun., 6 x 9 inches, 550 pages. First edition 1918. Price $5.00. McGraw-Hill Book Co., New York. In this book, which is a natural sequel to the same author's "Blast Furnace Construction," the Principles, Operation and Products of a Furnace form the subject matter. Part one is devoted to the identification of the various parts of the interior of furnace, to the special functions of the hearth, the bosh, and the shaft. The chemical reactions between carbon and its oxides, and iron and its oxides; the removal of deleterious elements, and the production of various fresh compounds are treated in Chapter II. Thermal equations, details of heat production, the twofold function of carbon, and solution losses take the reader to Chapter IV., which is devoted to the mechanical principles. The second section, containing ten chapters covers the whole field of operating a blast furnace, and one notices the author is careful to give his own opinions and to show by logical argument how he arrived at his conclusions. This is infinitely better than printing a host of generalities and suggestive statements, and leaving the reader without any concrete advice or guidance. In the third section the products of the blast furnace come under review and the three chapters are devoted to "Products depending solely upon chemical composition"; and "The chemical and physical properties of foundry irons." The influence of various elements is expounded, and the author has included, besides the commoner ones, information concerning the other elements such as chromium, nickel, titanium, and vanadium. In the last section commercial considerations and future possibilities are dealt with from various points of view. The illustration are well up to the average of those contained in technical books, and the matter is carefully arranged and comprehesively indexed.

---

Three Hundred Practical Shop Kinks. This is the title of a little book published by the McGraw-Hill Book Co., and the contents have been culled from the American Machinest. An almost endless variety of subjects are condensed into small paragraphs and it is impossible to read a single page without finding some scrap of useful information.

---

Refractories and Furnaces, by F. G. Havard, 6 x 9 inches, 356 pages, published by the McGraw-Hill Book Company, New York. Price $4.00. The author uses his introduction to deal with the history and development of the fire-clay and refractories industry and then devotes sixteen chapters to a practical consideration of his subject. The classification of refractory materials under acid, basic, and neutral characters prepares the way for a chapter on the relation between slags and refractory vessels and furnace linings. This chapter contains tables of the formation and melting temperatures of silicates, and the melting points of refractories. Another chapter is devoted to the preparation of silicious refractories, and includes the manufacture of various types of bricks. Refractory clays with their classification, composition, and the impurities commonly associated with them are dealt with in Chapter IV, together with the operations incidental to the production of bricks, slabs, and shapes of commercial utility. A most important section of the book is that devoted to the preparation of the basic and neutral refractories, and such materials as magnesia, steatite, chromite, bauxite, carbon, carbon-silicon compounds, and asbestos are all dealt with, and advice given as to the linings of various types of furnaces. Chapter VI. is devoted to the refractories used in the metallurgy of iron and steel; VII. to those used in the metallurgy of copper, and VIII. serves the same purpose for the metallurgy of silver. The remainder of the book is given over to the refractories used in chemical and electro-metallurgical industries, the application of common refractory bricks in industrial furnaces, the production of hollow ware, and a comprehensive accumulation of useful information. The latter includes sections on the testing of refractory products, thermo-physical properties, heat measurements and an appendix giving the sizes and shapes used in constructing furnaces. This book should be on the shelves of all those interested in metallurgical operations and is the best treatise on "refractories" with which we are acquainted.

---

## OFFER BY-PRODUCT FUEL

Cleveland, May 28. — Local by-product interests now are offering some coke to foundries in this district at the fixed price of $8.75, plus the switching charge. Sales are being limited to spot delivery. The offering is from a surplus created by better coal supplies.—Iron Trade Review.

## D. H. McDOUGALL,

### General Manager Dominion Steel Corporation.

More and more of our big business men are native-born. A few years ago one would be correct in surmising that the head of a great steel corporation, the manager of a mine or the president of a great transportation system would be an American. To-day we find Canadians directing the majority of our great industrial corporations, a condition of affairs which is extremely gratifying to those of us who believe that Canadians are equal in mentality to any people on earth.

Mr. D. H. McDougall, General Manager of the Dominion Steel Corporation is a case in point. Mr. McDougall was not only born in the coal fields of Cape Breton, but he started to work at the very bottom. In fact, the progress of the former pit boy, now the General Manager of a corporation which employs over a half score thousand workmen, is one of the most interesting incidents in the history of Canadian industry. The General Manager of the Dominion Steel Corporation is still on the sunny side of forty, and if he has been able to achieve as much as the records show in his 39 years, who can say what he will be able to accomplish if he lives out the allotted "three score and ten" of the Psalmist. From a physical standpoint, the indications are that the subject of this sketch will live out his allotted span. He is a husky lad and has not allowed his many arduous duties to interfere with his outdoor sports and love of athletics. Many a lad in the mine and mills around Sydney knows D. H. as a hard hitting amateur boxer. Others know him as a fisherman, a hunter, a horseman, a swimmer; in brief as an all-round athlete.

As stated above, D. H. McDougall began his working career as a pit boy in a Cape Breton coal mine. In many respects he differed not one iota from the other pit boys who toiled long hours in the Dominion Coal Company's collieries, but underneath the grime of the coal dust there were the stirrings of ambition. This Scotch lad did not always intend to be a common workman. As a mere lad he improved his nights by taking a correspondence school course, and by reading everything he could lay his hands on that was in any way related to the coal mining industry.

As the opportunity presented itself, he turned from the actual mine operations to the company's machine shops and there served as an apprentice and later as a mechanic. As he progressed in the scale of work he made still greater efforts to improve himself for what was ahead. Every possible moment he could spare he put in the Mining School, at Dalhousie University studying mining and surveying. Eventually, he became surveyor for the Dominion Coal Company. A little less than twenty years ago, when the Dominion Steel Company commenced to build its plant at Sydney, he joined that young company as surveyor, and worked with them while the company was laying out its plant. From surveyor he became field engineer and then went into the drafting department. Then followed his only break from the scenes of his youth. For two years Mr. McDougall lived in New York where he was Assistant Engineer of the New York Central Railroad, a training which has stood him in good stead, but even here he attended night school and studied hard in order to better himself.

Returning from New York, he became Manager of the Steel Co.'s Iron Mines at Wabana, Newfoundland. After four years there he was made superintendent of all the company's mines and works. Ten years ago he was made Assistant General Manager of the Dominion Coal Company, as well as holding the position of Superintendent of Mines for the Dominion Steel Corporation. Three years later he was made General Manager of the Dominion Coal Company, and two years ago General Manager of the Dominion Iron & Steel Company, the Dominion Coal Company, the Sydney and Louisburg Railway, the Cumberland Railway and Coal Company, the James Pender & Company plant at St. John, N.B., and the Sydney Lumber Company at Dalhousie, N.B.

In many respects, McDougall is an ideal man for the position he now occupies. It is well known that some 10 years ago a bitter law suit was being carried on between the Dominion Coal Company and the Dominion Iron & Steel Company, few dreaming at that time that these two bitter rivals would one day come together and be carried on as one organization. When the matter was finally settled before the Privy Council in England the two corporations decided that it would be better to co-operate than to continue their old policy of war to the knife. Each company fitted into the other's scheme of operations and history has subsequently shown that the two can be operated much more effectively as a single corporation than as two separate antagonistic companies. In all the years when law suits were the order of the day, D. H. McDougall served his apprenticeship, first with one and then with the other. He knew both businesses from the ground up. In the case of the Coal Company, he actually started underground, and in the case of the Steel Company helped lay out the buildings which afterwards grew to their present dimensions. When the two companies came together, no better man could be found for the administration of their joint activities.

That the General Manager of the Dominion Steel Corporation has a man's job on his hands can be shown by a casual review of the following figures. Before the war depleted its staff the company annually produced 5,000,000 tons of coal, of which some 2,000,000 tons found its way up the St. Lawrence to the industries located along that river. In those days the company employed over 11,000 men in its coal mines, operated its own fleet of steamers and had its own bunkering plants at many harbours on the Atlantic seaboard and on the St. Lawrence. To-day the Dominion Steel Corporation are large producers of coke. It operates its own by-product ovens and is installing at the present time two batteries of 120 Kopper by-product ovens. It operates its own electric furnaces, has 10 open hearth furnaces, a Bessemer plant and a mixer plant, while a new steel plate mill to cost several millions is now being erected. For its output it turns out sheet steel, shrapnel steel, high explosive steel, rods, bars, wire, nails and 57 other varieties of products.

In the olden days coal companies wasted all the valuable by-products. In those days coal was the only commodity worth while. The screenings were thrown aside, while if they made coke it was in the old beehive ovens, where all the valuable by-products were lost. To-day, the company at Sydney use the by-product ovens and as a result are getting the following valuable commodities:—

Toluol, benzol, napthalene, xylol, sulphuric acid, sulphate of ammonia and coal tar. Some of these are used in making explosives, others in dyestuffs and still others in the drug and chemical trade. In this way the Dominion Steel Corporation is not only making more money for its shareholders than was the case a few years ago, but it is laying the foundation for new and important industries in the country, which will have a far reaching effect on German competition when the war ends.

In all of this modern development, D. H. McDougall has borne a large part. It was due to his vision, his grasp of details, his knowledge of world markets and his abiding confidence in the future of his company and country that the Dominion Steel Corporation occupies its present proud place. The company has been a big factor in the production of war materials, and at the same time has laid broad and sure and deep its foundations for after-the-war business. In steel-making and coal mining, the Dominion Steel Corporation has long held a pre-eminent position, but to-day its new industries, called into being by the stress of war, bid fair to out-strip and surpass the old basic industries. Just what the manufacture of chemicals, dye-stuffs and various other by-products will mean is hard to say. McDougall grows enthusiastic as he dilates on their possibilities, and he ought to know, for they are his children. When the future history of this corporation comes to be written, a big share of its progress and development must be credited to one, D. H. McDougall.

---

## W. C. FRANZ.

### The Head of the Lake Superior Corporation.

By J. C. ROSS.

It may well be a debatable point as to which is the greater; the man who conceives an idea or the individual who transforms that dream into a reality. Some score years ago a man gifted with an unusual vision saw immense possibilities at the Canadian Soo, that little out-of-the-way place occupying a stratgetic position in a north-western Ontario point. Great iron ore deposits were in the neighbourhood, while vast pulp forests, unlimited water powers, excellent shipping facilities and many other natural resources made the place an ideal one for the establishment of a great industry. In course of time steel mills were erected, pulp and paper plants called into being, the water powers developed, railroads built to connect the plants with shipping centres and the Lake Superior Corporation was launched on its career.

Then came troublesome times: To co-ordinate and unite the many industries established there, to properly finance them and in brief to make the plant into a going concern proved to be a herculeanous task. The next few years were beset with difficulties. Man after man assumed the presidency of the company and tried to make it into a paying concern. It remained for William Charles Franz to crystalize into realities the dreams and plans made a score of years before by Mr. F. H. Clergue.

Franz, who is now President of the Lake Superior Corporation, of the Algoma Steel Corporation, of the Cannelton Coal & Coke Co., and of the Lake Superior Coal Company, is an American by birth, but he has so identified himself with the industrial and economic life of the Dominion that he is now a good "Canuck." If the Osler theory were put into practice, W. C. Franz would be relegated to the scrap heap as he is past the period of usefulness indicated by the famous doctor. Franz was born in Ohio in 1871, received a normal school education and then as a lad in his teens went railroading.

After a period of eleven years with the Toledo and Ohio Central Railway he joined the Hocking Valley Railway where he served as train-master and superintendent for five years. Then came a period of railroad construction work and coal development in West Virginia. When the Lake Superior Corporation were seeking for a man to develop their ore deposits they picked on Franz and took him from West Virginia. He came to the Soo in 1908, was made Vice-President of the various corporations five years later, and a year or more ago elected to the Presidency.

In some respects there is less known about the Lake Superior Corporation than about any of the other great steel manufacturing industries in the Dominion. This is probably due to the fact that this company's plant and head offices are located in a place which is off the beaten track, and consequently the fierce limelight of publicity does not beat upon Franz and his band of cohorts. In a measure, it is also due to the policy of the corporation's head, as it was said of the famous Lord Roberts, "He's little and he's wise, And he's mighty for his size, And yer don't advertise, Does yer Bobs?"

In spite of this aversion to publicity, the President of the Lake Superior Corporation has been sawing wood, or as it might be more correctly stated, smelting iron since the outbreak of hostilities. This corporation has produced more steel than any other in the Dominion and consequently has been a very big factor in the race to produce sufficient munitions and other war supplies to smother the Huns. They talk very little, but they do things up there at the Soo.

One of the employees of the Soo Corporation in talking about his chief said, "There are often platitudes uttered in regard to heads of corporations, and sometimes we are told that the men love their employer. In the case of the 'Soo' employees and Mr. Franz that is absolutely true, the men do love him, and have very good reasons for doing so. Mr. Franz is probably the most considerate employer of labour we have in Canada and this consideration and thoughtfulness for the welfare of his men is expressed in so many ways and under so many circumstances that he has the devoted and whole-souled support of every one of his workmen." That in brief sums up the general impression of Mr. Franz. It is the verdict of those who know him best, and it certainly is a striking tribute to the man's character and as an employer of labour.

There is no doubt but that the corporations over which Mr. Franz presides will make great strides in the next few years like so many of our other big industries. The Soo Companies have found themselves during the war. Their output of munitions, the demand for steel rails and a thousand and one other commodities demanded by the insatiable Mars has meant that the plant has worked to capacity. It has not only built up a big business for itself, but it has strengthened its position financially, so that it is only reasonable to expect that when peace comes and they turn from the making of munitions to the peaceful industries that the same progress will be continued. Much of the success which has come to the Soo Corporations must be attributed to the man who presides over their distiny—W. C. Franz.

# The Occurrence and Testing cf Foundry Sands

By L. HEBER COLE,
Canadian Mining Institute, March, 1917.

The need in Canada for foundry moulding sands of different grades suitable for different classes of castings has increased greatly in the last few years, and has led the Mines Branch to investigate many Canadian sand deposits to determine their suitability for this class of work. At the present time a large part of the sand used in Canadian foundries is imported; and, although, in a number of places, local deposits furnish small quantities to foundries in the immediate neighborhood, no deposits have been opened on such a scale as to furnish properly graded sand to the foundry trade of Canada; and the supply for this market is now being drawn mostly from the United States.

In the summer of 1914 the investigation of the sand deposits of Quebec by the Mines Branch was commenced, the field work being continued during the seasons of 1915 and 1916. The scope of the investigation has since been extended into eastern Ontario. It is hoped that, during the coming season (1917), field work will be carried on in western and southwestern Ontario.

In the course of the regular field work so far accomplished, several deposits of sand were encountered, which, based on the field examination, gave promise of being suitable for moulding sands. Samples of these were taken and sent to the Mines Branch Laboratories, Ottawa, for examination and testing.

### Foundry Sands in General.

Foundry sand may be divided into two main classes:

(1) Moulding sands, or the sand which is actually used to make the mould, into which the molten metal is poured; and,

(2) Core sands, which are utilized for making the cores that occupy the hollow spaces in the casting.

The material used for foundry sands varies greatly, according to the nature of the casting, the metal to be poured, the part of the mould, and the foundry where it is employed. Thus, materials varying from a heavy, clayey loam to a coarse river sand are used according to the nature of the casting being made. A sand which is suitable for a coarse casting would not be satisfactory for fine work; frequently also an entirely different grade of sand is used for making the cores. Again, in green sand moulding the sand used differs from that used in dry sand moulding, where the moulds and cores are first baked. The practice in various foundries is so diverse and the sand employed for different grades of castings varies so widely that it can readily be seen that it is almost impossible to lay down a hard and fast set of standards to which a sand must conform, in order to be called a foundry sand. This is partly due to the manner in which the average foundry man looks on his sand, and partly to the lack of definite knowledge as to the behaviour and action of certain sands with relation to the castings made in them. The sand used in most cases is employed on the advice of the head moulder in the foundry, who generally trusts to his experience in handling sands as to the suitability of a particular sand for the work in hand. The appearance of the sand to the eye, and whether it will retain the impress of the hand when damp are generally all the tests to which the sand is subjected. If the moulder does not like the look of the sample submitted, and, especially, if he knows it to be a local sand, it is frequently condemned as not suitable without further examination. While this condition of affairs exists, it will be hard to adopt any standards for moulding sands, but it is conceivable that, when the qualities of different sands in relation to the class of castings made in them have been more fully studied, it wil most likely be possible to formulate by a series of laboratory and foundry tests, a set of standards with limits within which a sand may be determined to be suitable for a certain class of casting by systematic laboratory and foundry tests.

### The Occurrence of Moulding Sand.

1. **Natural Moulding Sands.**—Moulding sands occur in two main types of deposits, but variations of these types may be encountered. These are: (a) from flood plain deposits; and (b) re-washed ancient beach sands.

In respect of the first mentioned deposits: from the nature of a moulding sand, it being essentially a silica sand with each individual grain coated with a bonding material, one would expect to find it occurring where deposits of sand and clay were constantly being intermingled and worked over by water, and, therefore, moulding sands in flood plain deposits are of quite common occurrence. In these beds the sand and clay have been well and intimately mixed by the river currents, and deposited on the higher levels in flood time, the excess of clay, being more minute, is carried off by the water. One would thus expect to encounter moulding sands of this character along the upper terraces of the large rivers of the country, such as the St. Lawrence; also along the banks of the ancient waterways.

The second class of deposits which are frequently encountered are of secondary origin. The sand bars and beaches of the ancient seas have been worked over by the waves as they recede, when new levels of the lakes and seas are formed. The washed material from these beaches consists of sand and clay, the former being deposited in greater abundance. It is in deposits of this class, which are found at a lower level than the old beaches or water margins, that moulding sand may be expected to occur. These deposits are, therefore, to be looked for in the vicinity of the ancient glacial lake margins, such as the Iroquois and Algonquin, which formerly occupied the Great Lake Basin; and also within the boundaries of the ancient lake Agassiz in Manitoba. Similar ponded water bodies in glacial times extending as far as the foot hills of the Rocky mountains in Alberta may also have deposits of this character within their margins.

W. C. FRANZ,
President, Algoma Steel Corporation, Ltd.

D. H. McDOUGALL,
General Manager Dominion Steel Corporation.

2. **Prepared Moulding Sands.**—The natural moulding sands referred to above comprise by far the greater part of the sand used in Canadian and United States foundry practice; but there are being employed increasing amounts of what may be termed "prepared moulding sands," and as the suitability of this class of sand becomes better known, there is no doubt that their use will be extended widely. These sands are prepared for use by crushing either sandstones which have a very friable bonding material, or else a decayed granite, or shattered sandstone having the fractures filled with a plastic material (such as kaolin, etc.). These sands have no fillers added to them, but perhaps, have to be screened and washed as well as crushed before being offered to the trade. Under this class may also be placed those earthy loams which, by washing, to remove part of the clayey content, may be utilized as a suitable foundry sand.

3. **Synthetic Moulding Sands.**—Many foundrymen have expressed the opinion that the present known

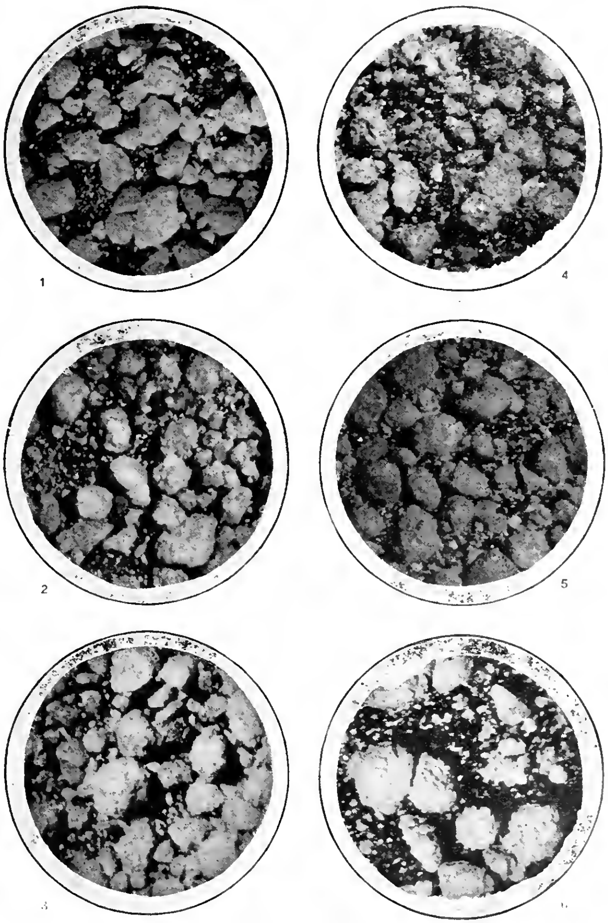



**Plate I.—Photomicrographs No. 3, Albany Sand.**
(Oblique reflected light—Magnification, 20 diams.)
1. Fresh Sand.
2. After first burn.
3. After second burn.
4. After fourth burn.
5. After fifth burn.
6. After sixth burn.

deposits of high grade natural moulding sand will become exhausted, necessitating resort to artificial or synthetic moulding sands made by intimately mixing finely crushed quartz, or clean sharp sand, with clay, so that each grain of quartz would become uniformly coated with the clay. It can readily be seen that sand so prepared will have decided advantages over the sands at present in use, in that it will be possibe to manufacture a uniform material for the class of work required, and also that variations in the material can be made at will to meet the requirements of the trade.

## The Testing of Moulding Sands.

The examination and testing of a moulding sand deposit can be divided into two parts: (a) The field examination of the deposit; (b) Laboratory examination and testing of the sand.

**Field Examination of a Sand Deposit.**—In undertaking a field examination of a moulding sand deposit, there are several points to be taken into consideration:

1. Nature and extent of deposit (area and depth).
2. Uniformity of sand.
3. Transportation facilities.
4. Location, with respect to larger markets.

The importance of a field examination can readily be grasped. A sand may be suitable for foundry work in every way; but, if it is not in sufficient quantity, easily exploited, and is not favourably situated to the larger markets for this class of material, the deposit is of little value as a commercial venture.

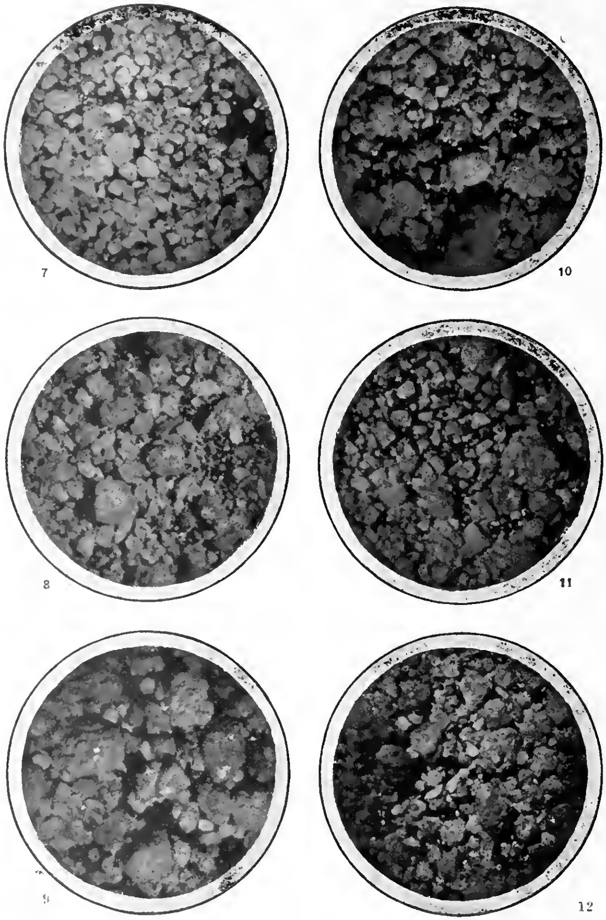


Plate II.—Photomicrographs Brockville Sand, (Fleck's Foundry.)
(Oblique reflected light—Magnification, 20 diams.)

7. Fresh Sand.
8. After first burn.
9. After second burn.
10. After third burn.
11. After fourth burn.
12. After fifth burn.

The method of field examination employed by the writer is as follows: The area is tested by drilling test holes with a 6-inch post hole auger drill, in a sufficient number of places to determine the extent and depth to which the sand is encountered. These holes are indicated on a map of the area and the boundaries of the sand plotted. The sand encountered in the drill holes is carefully examined with a hand magnifying glass to note any marked difference in its character. Samples are taken from these holes and mixed together to obtain a uniform sample for testing in the laboratory. If more than one grade is noted, separate samples are taken.

**Qualities of a Moulding Sand to be determined.** — When commencing the laboratory tests of the samples taken in the field, the question arose, "What are the requirements of a good moulding sand?' The literature on moulding sands so far is very meagre, and any systematic series of laboratory tests to determine a sand's suitability for a foundry sand are confined to work done by several of the State Surveys, the Bureau of Standards, Washington, and the American Foundrymen's Association. The opinions of the investigators appear to differ greatly both as to the series of tests necessary, as well as the method by which they are to be carried out.

From a study of the literature available, and after numerous conversations with practical foundrymen throughout the country, it was found that the qualities to be taken into consideration in the examination of a moulding sand are as follows:

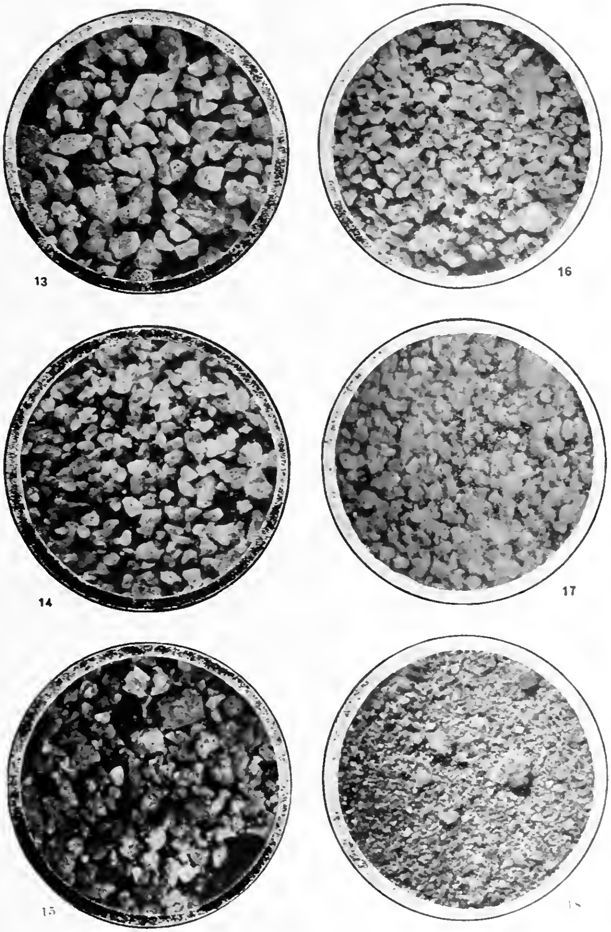


**Plate III.—Photomicrographs Brockville Sand, (Lawson's Foundry.)**

(Oblique reflected light, Magnification, 20 diams.)

13. After first burn.
14. After third burn.
15. After fourth burn.
16. After fifth burn.
17. After seventh burn.
18. No. 0 Albany fresh sand.

**Texture.**—The texture or fineness of grain is one of the most important points of a sand. This will necessarily vary, according to the size and kind of casting to be made in it. Hence, it is at once obvious that sands will have to be selected to suit the class of work for which they are required, or, in other words, sand which is suitable for light work would, perhaps, be a failure when used with heavy work, or vice versa.

[1] The sands referred to here are moulding sands proper. Core sands vary widely in different localities, and mostly require bonding material to be added to them. They will be treated separately at a later date.

**Refractoriness.** The capability of resisting effectively the destructive action of the heat of the molten metal is of importance. The greater the size of the casting, the longer it will be in cooling, hence the sand in contact with the metal will be subjected to the intense heat for a longer period of time. It is thus obvious that for large castings a more highly refractory sand will be required than for small castings.

**Bonding power.** Moulding sands should possess sufficient bonding power or cohesiveness of their particles to each other to retain firmly the shape and form of the pattern, and also to resist the pressure of the molten metal in the mould. This bonding power depends partly on the clay mixed through the sand particles, and the clay coating on the individual grains, and partly on the nature of the grains, whether they are angular or rounded, coarse or fine. As a rule, the finer and more angular the sand grains, the greater the bonding power.

**Permeability.** One of the properties of a moulding sand which helps to determine its suitability for foundry use is that of allowing the escape of gases through it. The molten metal develops gases which exert a pressure on the face of the mould, and, unless the spaces between the grains are sufficient to enable the gases so generated to escape freely, there will be serious danger of creating scabs or causing the castings to blow on this account. Obviously, then, heavy castings will require a more open sand of a coarser grained texture than will fine castings.

**Durability.**—The durability or life of a sand is of extreme importance. There are many sands which, when used once or twice, lose some of their desirable qualities, and soon become "dead" or useless. Obviously, the sand in contact with and adjacent to the molten metal will suffer most. The present practice is to screen out the coarse particle and add fresh sand to the remainder. Hence, the greater the durability of a sand, the better it is, as it will last

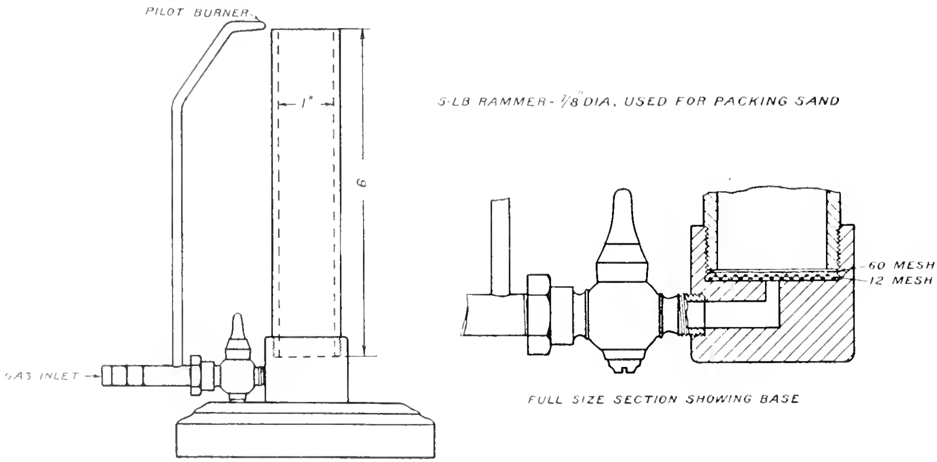



Fig 1. Permeability Apparatus for determining Permeability of Moulding sands.

longer, and it will not be necessary to add fresh sand to it so frequently.

In deciding on methods to employ in examining the samples taken, in order to ascertain their characteristics regarding the qualities just enumerated, it was decided to proceed as follows:

The sample for examination is first passed through a 10 mesh screen, and what is retained on this screen is considered the sample for examination; and all tests are conducted with this material.

**Texture.**—The texture is determined by making a granulometric analysis of a representative sample, generally 100 grams. This is passed through a series of Tyler Standard Screens, by shaking thoroughly on a mechanical shaker; the material retained on each screen being collected, weighed and noted. If the sample in the first place weighs 100 grams, the weight recorded as retained on each screen is the percentage retained on that screen, and the cumulative percentage of all material that would be retained on any given screen, if that screen alone were employed can readily be determined. The screens used for this test and the form used for tabulating the results are as follows:

SCREEN SCALE RATIO 1.414

| Indicate the Screen Crushed through and also First Retaining Screen | Openings Inches | Milli metres | Mesh | Diam. Wire Inches | Sample Weights | Per Cent | Per Cent Cumulative Weights |
|---|---|---|---|---|---|---|---|
| ...... | 1.050 | 26.67 | | .149 | ...... | ...... | ...... |
| ...... | .742 | 18.85 | | .135 | ...... | ...... | ...... |
| ...... | .525 | 13.33 | | .105 | ...... | ...... | ...... |
| ...... | .371 | 9.423 | | .092 | ...... | ...... | ...... |
| ...... | .263 | 6.680 | 3 | .070 | ...... | ...... | ...... |
| ...... | .185 | 4.699 | 4 | .065 | ...... | ...... | ...... |
| ...... | .131 | 3.327 | 6 | .036 | ...... | ...... | ...... |
| ...... | .093 | 2.362 | 8 | .032 | ...... | ...... | ...... |
| ...... | .065 | 1.651 | 10 | .035 | ...... | ...... | ...... |
| ...... | .046 | 1.168 | 14 | .025 | ...... | ...... | ...... |
| ...... | .0328 | .823 | 20 | .0172 | ...... | ...... | ...... |
| ...... | .0232 | .589 | 28 | .0125 | ...... | ...... | ...... |
| ...... | .0164 | .417 | 35 | .0122 | ...... | ...... | ...... |
| ...... | .0116 | .295 | 48 | .0092 | ...... | ...... | ...... |
| ...... | .0082 | .208 | 65 | .0072 | ...... | ...... | ...... |
| ...... | .0058 | .147 | 100 | .0042 | ...... | ...... | ...... |
| ...... | .0041 | .103 | 150 | .0026 | ...... | ...... | ...... |
| ...... | .0029 | .074 | 200 | .0021 | ...... | ...... | ...... |
| Pass | .0029 | .074 | 200 | .0021 | ...... | ...... | ...... |
| | | | | | Totals | ...... | ...... |

In order to gain some idea of the relative fineness of the sand, and to be able to express this in one figure, a more convenient form than the whole granulometric analysis, the average fineness of the sample is calculated. The average fineness is determined as follows: The material passing through each screen and retained on the next smaller one is multiplied by the mesh of the screen passed through. The results obtained are totalled and divided by 100, the resultant being the average fineness. In other words, if all the grains of the sample were reduced to a uniform size, they would just pass through a screen whose mesh was equal to the average fineness of the sample. For example. The granulometric analysis of a sand is:—

| | Mesh | % | The calculations for average fineness will be: |
|---|---|---|---|
| Retained on. .. | 10 | .. .. | |
| " .. .. | 14 | ... | 14 x 0.10 = 1.40 |
| " .. .. .. | 20 | 0.10 | 20 x 0.12 = 2.40 |
| " .. .. .. | 28 | 0.12 | 28 x 0.23 = 6.44 |
| " .. .. .. | 35 | 0.23 | 35 x 0.65 = 22.75 |
| " .. .. .. | 48 | 0.65 | 48 x 0.72 = 34.56 |
| " .. .. .. | 65 | 0.72 | 65 x 1.50 = 97.50 |
| " .. .. .. | 100 | 1.50 | 100 x 13.01 = 1301.00 |
| " .. .. .. | 150 | 13.01 | 150 x 22.30 = 3345.00 |
| " .. .. .. | 200 | 22.30 | 200 x 61.37 = 12274.00 |
| Through .. .. .. .. | 200 | 61.37 | Total .. .. .. 17085.05 |

$$\frac{17085.05}{100} = 170.85$$

**Microscopic Examination.**—It has been found that the free use of the microscope in examining the sand, both fresh and after being burned, has added valuable data which help materially in determining a sand's suitability for a moulding sand. Microphotographs of the sand are also valuable for comparison.

**Refractoriness.**—The refractoriness of a sample is determined by preparing a cone of the sand and heating it to fusion in an electric furnace along with standard Segers cones, and noting at what cone the sand fuses.

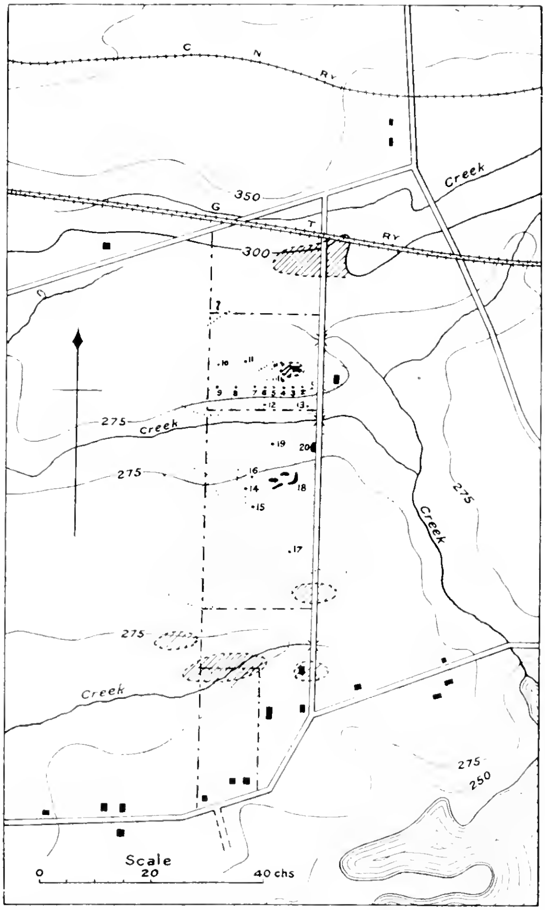
**Bonding Power.**—The determination of the bonding power of a moulding sand from tests either in a laboratory or in actual foundry practice presents many difficulties, and the methods so far devised give only relative results, and these are variable according to the skill of the operator making the tests. The tentative method adopted for these tests is similar, with a few slight modifications, to the method employed by the Bureau of Standards at Washington, D.C. By this test the transverse strength of the sand is determined. A known quantity of a particular sand is weighed (generally 500 grams), and mixed with a definite quantity of water so that the sand will just hold together. From this sand a test bar is made, one inch square, in section, by 12 inches long. This is moulded in a snap flask on a piece of plate glass. The sand is packed in the flask as uniformly as possible from end to end with the thumb and forefinger of each hand, and smoothed with a trowel. The flask is removed, and the test bar is left on the plate. The glass plate and bar are then weighed, the weight of the plate glass having been previously determined, the weight of the test bar is obtained by difference. While the test bar still retains its moisture, it is gently and steadily shoved lengthwise over the edge of the glass plate until it breaks off and the length breaking off is noted. Continuing this operation, successive portions are broken off and the average length of the overhang, at the breaking moment, is determined. The weight of the bar in grams, being known, the transverse strength of the specimen can be calculated from the following formula:

$$S = \frac{\text{Wt. of bar (in gms.)}}{4} \quad \frac{L^2 \text{ in inches}}{153.6} \text{ where}$$

S = transverse strength.

L = length of overhang in inches.

A series of tests were conducted on each sample, taking 5 cc. additional water each time until the




Moulding Sand Rock Outcrop Test Pits Fence

Fig. 2. Sketch map showing areas underlain by moulding sand on the property of T. B. Bresee, and others, $2\frac{1}{2}$ miles west of Brockville, Ont.

test bar deforms on attempting to shove it over the edge of the glass. An average of the transverse results obtained by using varying quantities of water is taken to represent the transverse strength of the specimen.

**Permeability.**—The method adopted for the determination of the permeability of a moulding sand is, as far as the writer knows, entirely new. Investiga

tions along this line have consisted in passing either a definite amount of water or air through the sand, and noting the time required. Both these methods introduced a serious error, since once the first air or water had passed through the sand, channels would be opened through the sand which would greatly facilitate the flow of the remainder of the air or water. To overcome this difficulty the apparatus shown in Fig. 1 was designed, and the results so far obtained have been extremely satisfactory. With this apparatus, ordinary illuminating gas at a definite pressure is passed through the sand, and ignited the instant it reaches the top of the sand tube. The interval of time required from when the gas is turned on to the moment of ignition, is noted by a stop watch, thus determining the initial passing of the gas, and overcoming the error due to the forming of channels through the sand. Three tests are run on each sample, using fresh sand each time. The average time is taken as the permeability factor. The sand is packed uniformly in the cylinder by placing in a small quantity at a time (about 1 inch of sand), and pressing it down for 5 seconds, using a 5 lb. weight. When the cylinder is filled, it is struck off flush on top with a straight edge.

**Durability.**—All the foregoing tests may be regarded as being in the nature of a preliminary enquiry to determine whether the sand so tested can be classed as a moulding sand and passed on to the durability test, which must always be regarded as the final one by which a sand from an unworked deposit is accepted or rejected. The durability test is made under actual working conditions, hence defi- knowledge of the usefulness of a sand can be determined.

If a sample when subjected to the previously described tests, has proven satisfactory, within certain accepted limits, a larger sample is obtained, and tested in a commercial foundry, where castings are being made of the class to which the sand is deemed best suited. A pattern is chosen, generally one which comes in the general run of the foundry, and the sand to be tested is used with this pattern. Care is taken to keep separately the sand in which the casting is made, and another cast from the same pattern is made, using this sand without adding any fresh sand to it. This operation is repeated until the sand shows signs of becoming "dead." After each cast, the sand is thoroughly mixed and a sample taken. These samples are submitted to all the laboratory tests previously described, and any differences are noted. For means of comparison, a duplicate series of castings is made in parallel with the sand being tested, employing some well-known moulding sand.

## Results of a Test on a Moulding Sand Collected Near Brockville, Ont.

To illustrate the methods employed in the examination and testing of a moulding sand the following report of a test on a deposit of moulding sand from near Brockville, Ont., will serve. This deposit was one encountered in the course of the regular field work, in connection with the investigation of the sand deposits of Ontario.

**Field Examination.**—The deposit in question lies $2\frac{1}{2}$ miles to the west of the town of Brockville, Ont., between the G.T. Ry. line (Montreal to Toronto) and the river road. (Brockville to Belleville.)

As far as could be determined in the time at the disposal for the field examination the area underlain by moulding sand is of considerable extent, although detailed work was only carried out on the area shown in the sketch map, Fig. 2. No time was available to trace the extension of the deposit to the eastward or to the west, but this will be done during the field season of 1917.

The topography of the immediate district is decidedly rugged. The drift with which the district is overlain consists of rolling hills of boulder clay, sand, and gravel, through which numerous "islands" of bare rock protrude. These patches of bare rock consist to the north and northeast of Potsdam (?) sandstone and to the south and west of Laurentian granites. All outcrops of rock examined were well glaciated, and rounded, showing clearly defined striae.

By reference to the sketch map Figure 2, it will be seen that the area so far known to be underlain by moulding sand lies between and around the rock outcrops already mentioned. A stream passing through the deposit has revealed clay beneath the sand.

The sand lies beneath a thin layer of loam averaging about 6 to 12 ins. thick. In most places where tested there was a definite line of demarcation betwen the loam and the sand.

The sand is fairly uniform over the whole deposit shown in the sketch, and will average 2 ft. 4 ins. thick. In all the test holes and pits, only two boulders were encountered, each about $2\frac{1}{2}$ ins. diameter, so that the sand appears to be free from stones in the area examined. At the edges of the deposit, where the sand and boulder clay are in contact, it may be that the boulders are more frequent.

In order to determine the nature and extent of the deposit a number of test pits were examined and drill holes bored as indicated on the sketch map. The results obtained from these pits and holes are as follows:—

### Results of Test Pits and Borings on Brockville Sand Deposit.

| Hole or pit | Amount of stripping | Thickness of moulding sand | Material below moulding sand |
|---|---|---|---|
| 1 | 8 ins. | 3 ft. 8 ins | Sand and clay interbanded. |
| 2 | 8 " | 3 " 4 " | " " |
| 3 | 14 " | 1 " 0 " | Sandy clay. |
| 4 | 12 " | 1 " 2 " | " " |
| 5 | 10 " | 1 " 6 " | " " |
| 6 | 10 " | 3 " 10 " | " " |
| 7 | 15 " | 1 " 9 " | " " |
| 8 | 8 " | 2 " 0 " | " " |
| 9 | 10 " | 1 " 10 " | " " |
| 10 | 7 " | 2 " 2 " | " " |
| 11 | 10 " | 2 " 6 " | " " |
| 11a | Stiff clay to a depth of 3 ft. | | |
| 11b | " " | " " | |
| 12 | 6 ins. | 2 ft. 0 ins. | Sandy clay. |
| 13 | 10 " | 1 " 6 " | " " |
| 14 | 4 " | 2 " 6 " | " " |
| 15 | 8 " | 2 " 6 " | " " |
| 16 | 6 " | 3 " 0 " | " " |
| 17 | 8 " | 2 " 0 " | " " |
| 18 pit | 8 " | 2 " 6 " | " " |
| 19 | 10 " | 2 " 8 " | " " |
| 20 pit | 4 " | 3 " 2 " | " " |

No idea can be given of the total tonnage of sand available as the complete boundaries were not located, but that there is a considerable quantity there can be no doubt, judging from the area tested.

**Preliminary Tests.**—A sample of 40 lb. of sand was taken when the deposit was first visited, and this was applied by the Alex. Fleck Limited foundry, Ottawa,

to make moulds for three iron castings, one at a time, using the Brockville sand, exclusively, each time. The weight of the casting was about 12 pounds and all three casts were perfectly satisfactory, having a good smooth surface free from scabs, and corners showing clean definition.

This preliminary test having proved satisfactory, two lots of 600 pounds each were dug and shipped by the writer to Ottawa without preparation in any way, in order to test the lasting and wearing qualities of the sand. Care was taken to see that the samples collected were representative of the whole deposit as far as could be ascertained. One shipment was taken to the foundry of Alex. Fleck, Limited, Ottawa, where the first tests were made; and the other 600 lb. was delivered at the brass foundry of Lawson Bros., Ottawa.

At both places the tests carried on were made under the supervision of the writer, who followed closely all the results obtained, and examined the sand and castings after each cast.

**Test of Sand at the Fleck Foundry.**—It was desired to gain an idea of the life of the sand when employed with fairly heavy pieces of casting. In order to obtain comparative results the same amount of fresh No. 3 Albany moulding sand, as used in this foundry, was taken and used side by side with the Brockville sand on the same pattern. After each cast, each sand was kept separate, thoroughly mixed, sampled, and used again. The piece cast was an iron flange in the shape of an L, 5 ft. long, 10 in. wide, and 1 in. thick, with a 3-in. flange 1 in. thick, on one side. The weight of the casting was approximately 200 lb.

Five castings were made in each sand under ordinary working conditions, the moulding being done on the two sands by the same moulder throughout, under the direct supervision of the foreman. Care was taken that each sand was thoroughly mixed after each casting. A sample of each sand was taken when fresh, and after each burn, and examined in the Mines Branch Laboratories. No fresh sand was added to either test and only the sea coal that was absolutely necessary was employed.

The castings were examined after each cast. There was no noticeable difference between those cast in either sand or from the first and fifth cast in the same sand.

**Test of sand at Lawson's Brass Foundry.**—The sand sent to Lawson Bros. was used in their brass foundry on general run of work, employing whatever pattern they needed each day. The Brockville sand was kept separate throughout and the cast was varied between brass and iron, all casting being small. The sand was mixed thoroughly after each burn and no fresh sand was added to it. Samples after every alternate burn were taken for examination. Seven casting in all were made in the same sand, the weight of castings varying from 12 to 50 pounds. Five were brass and two iron. All castings when examined showed clear, sharp, well defined edges, and the body free from scabs. No sign of burning appeared on any of the castings. A sample of the fresh Albany No. 0, as used in this foundry, was taken for comparison.

**Laboratory Tests.**

The samples for examination—obtained from the casting tests at the two foundries — were subjected to the following laboratory tests:

**Granulometric Test.**—The samples as brought from the foundries were each treated as separate samples. Each one was thoroughly mixed and quartered, and 100 grams taken, and put through a set of Tyler Standard Screens, on a mechanical shaker. The results obtained are tabulated in Table No. 1.

**Transverse Strength.**—The test for determining the transverse strength or bonding power of the sand was carried out in a similar manner to that employed in the Bureau of Standards, Washington, with the exception to the procedure followed there of always taking the same amount of water. A series of tests were made on each sample, varying the amount of water 5ccs. each time, and taking the average of results obtained as the transverse strength. The results of the tests are given in Table No. 2.

**Test for Refractoriness.**—A test for the refractioniness of the fresh Brockville sand was made by preparing a cone and fusing it in an electric furnace with Standard Segars cones. The test cone fused at cone 8 which is equivalent to 1290 degrees C. or 2354 degrees F.

**Miscroscopic Examination.**—The fresh sand, as well as the samples from each burn, were examined under a binocular microscope, and the following notes made:—

| | | | |
|---|---|---|---|
| 1 | No. 3 Albany fresh (Fleck's) | | Small grains, well rounded. Larger grains, semi-angular. Quartz predominant. Occasional grains of magnetite — all were coated with clay, and of uniformly yellowish color. |
| 2 | do | 1st burn. | Quartz grains in some cases have the clay partially burned off. Sintering is seen in a few cases in the smaller grains. In most cases sand grains are unchanged. |
| 3 | do | 2nd burn. | Similar to No. 2 with exception that the sand has a darker appearance, due to occasional grains having turned reddish in color from the oxidation of the ferric iron coating. |
| 4 | do | 3rd burn. | Sand has a darker appearance. Sintering more pronounced. Cementing of groups of the smaller grains together. Larger grains losing their clay coating to a small extent. |
| 5 | do | 4th burn. | Similar to No. 4 with the grouping together of the smaller grains more pronounced. |
| 6 | Albany | 5th burn. | Large grains have taken on the appearance of spongy masses due to the adhering of the smaller particles to them. Smaller particles are grouped and cemented together |

| | | | |
|---|---|---|---|
| | | | still further. Sintering quite pronounced. Occasionally edges of larger grains are fused. |
| 7 | Brockville fresh (Fleck's Foundry) | | Sand consists of fairly clean quartz sharp and angular with only a very thin film of clay coating. Magnetite, hornblende, feldspar, and mica visible. Light yellowish color. |
| 8 | do | 1st burn. | Sintering appearing. Sand assuming a darker color. |
| 9 | do | 2nd burn. | Sintering quite pronounced. Larger grains have smaller grains cemented to them, and the smaller grains commencing to group together in cemented masses. |
| 10 | do | 3rd burn. | Sintering and cementing together of small particles more pronounced. Sand grains showing decided effect of heat. |
| 11 | do | 4th burn. | Complete fusion in mass of some of the smaller groups of particles can be seen. The edges of most of the larger grains have become fused and present an appearance of water-worn sand. |
| 12 | do | 5th burn. | Sintering pronounced in most of the grains. Small grains are grouped together and well fused. Larger grains show fusion of sharp edges. Bonding coating has disappeared from the greater percentage of grains. |
| 13 | Lawson's Foundry | 1st. burn. | Coating slightly affected. No sign of sintering. Sand similar in appearance to original. |
| 14 | do | 3rd burn. | No sign of sintering. Coating only slightly affected. Otherwise similar to original. |
| 15 | do | 4th burn. | Same as No. 14. |
| 16 | do | 5th burn. | Same as No. 15 with slight signs of sintering. |
| 17 | do | 7th burn. | Slight sintering. Smaller particles in some cases cemented together. |
| 18 | No. 0 Albany Fresh | | Highly silicious sand. Uniformly graded and coated. Sand particles sharp and angular. Light yellow in color. |

Photomicrographs of each sample were taken, and are shown in Plates Nos. I, II, and III.

**Chemical Analysis.** — A chemical analysis of the Brockville sand was made, with the following result:

Ultimate Analysis.

| | | |
|---|---|---|
| $S_2O^3$ | 74.35 | per cent. |
| $Fe_2O_3$ | 1.10 | " |
| $FeO$ | 1.48 | " |
| $Al_2O$ | 12.63 | " |
| $CaO$ | 2.60 | " |
| $MgO$ | 1.06 | " |
| $Na_2O$ | 2.73 | " |
| $K_2O$ | 2.15 | " |
| $H_2O$ | 1.90 | " |

It is questionable whether much information can be obtained from ultimate analysis, beyond a very general indication of the refractoriness. It is moreover frequently very misleading; hence it is deemed advisable to omit it in future.

**Permeability Test.** — The permeability test shows that the permeability increases the oftener the sand is subjected to the molten metal. Results are given in Table III.

**Conclusions to be Drawn from Results of Tests.**

An examination of the results obtained from the series of tests carried out on this sand brings out some interesting facts regarding the properties of moulding sands and their behavior under actual working conditions.

**Granulometric Analysis.** By comparing the No. 3 Albany screen analysis with the Brockville sand used at the Fleck Foundry, it will be seen that there is in both cases increase in the coarseness of the particles, the oftener the sand is submitted to the heat of the molten metal. In the case of the No. 3 Albany, this increase is uniform and very gradual; whereas with the Brockville sand the changes are abrupt and not uniform, showing a tendency of the smaller particles to become cemented together. On the other hand, the Brockville sand as used at the Lawson Foundry, shows only a slight increase after each burn, and the increase is uniform.

**Tests for Transverse Strength.** In examining the results obtained by the tests for transverse strength it is seen that both in the No. 3 Albany and the Brockville sand used at Fleck's, there is a gradual decrease in the amount of water used and also a decided decrease in the transverse strength. In the case of the Brockville sand used at Lawson's the decrease in strength is only slight.

**Microscopic Examination.** By microscopic examination of the samples obtained after each burn and also the fresh sand, some interesting data were secured. The Brockville sand (Fleck's), shows decided sintering and cementing together of the smaller grains to the larger ones with a consequent decrease in bonding power. This sintering and cementing together of the particles is shown plainly in the photomicrographs, Plate II. The sand tested at Lawson's shows very little alteration when examined under the microscope.

**Chemical Analysis.**—The conclusions to be drawn from the chemical analysis are so slight that it can be dispensed with in an examination of this kind, the physical tests being the only ones of value.

### Summary of Results.

Summing up the results obtained in the tests, it appears that the Brockville sand is a suitable moulding sand for stove plate and similar light work in iron, but although the heavier castings made in it were seemingly satisfactory it would not be advisable to use it on very heavy work, as the possibility of its failure would be greater than with the coarse sands in general use. Because of the fineness of its texture with the resultant tendency to sinter when exposed repeatedly to the molten metal, it appears to answer all requirements for use in the general run of brass foundry work. With a little care in selection and grading at the pit several grades uniform in texture could be obtained.

**TAB LE I**

**Granulometric Tests.** **Cumulative Per Cent.**
Cumulative per cent of material retained on given meshes.

| | | 6. | 8. | 10. | 14. | .20 | 28. | 35. | 48. | 65. | 100. | 150. | 200. | 200+ | Average Fineness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Fleck's) Brockville | Green sand | ..... | ..... | ..... | ..... | .09 | .24 | .46 | .69 | 1.63 | 8.85 | 49.95 | 77.21 | ...... | 132.9 |
| | 1st. Burn | ..... | ..... | .27 | .80 | 2.01 | 4.14 | 8.83 | 19.54 | 28.83 | 40.27 | 67.83 | 82.87 | ...... | 102.0 |
| | 2nd. " | ..... | ..... | .18 | .36 | .78 | 2.00 | 4.88 | 12.00 | 16.95 | 28.80 | 60.27 | 80.79 | ...... | 114.4 |
| | 3rd. " | ..... | ..... | .41 | .89 | 2.01 | 3.91 | 8.84 | 20.18 | 27.70 | 41.96 | 68.35 | 83.00 | ...... | 94.7 |
| | 4th. " | ..... | .30 | .80 | 1.26 | 2.17 | 4.46 | 8.68 | 19.70 | 29.03 | 41.23 | 70.26 | 85.12 | ...... | 99.21 |
| | 5th. " | ..... | .31 | .74 | 1.41 | 2.46 | 5.15 | 10.98 | 24.60 | 34.05 | 48.09 | 72.46 | 80.02 | ...... | 96.6 |
| No. 3 Albany (Fleck's) | Green sand | ..... | ..... | .40 | 1.00 | 1.98 | 4.65 | 13.08 | 34.03 | 50.65 | 65.96 | 78.51 | 83.77 | ...... | 81.3 |
| | 1st. Burn | ..... | ..... | .69 | 1.30 | 2.47 | 4.74 | 12.37 | 32.82 | 50.66 | 66.85 | 79.58 | 85.55 | ...... | 79.7 |
| | 2nd. " | ..... | .36 | .91 | 1.56 | 2.76 | 5.55 | 13.72 | 36.09 | 52.11 | 68.03 | 79.65 | 86.01 | ...... | 78.2 |
| | 3rd. " | ..... | .40 | 1.03 | 1.86 | 3.52 | 6.68 | 16.13 | 36.52 | 54.18 | 69.33 | 82.22 | 92.34 | ...... | 77.5 |
| | 4th. " | .42 | .92 | 1.43 | 2.13 | 3.39 | 6.89 | 16.53 | 39.35 | 54.37 | 70.24 | 82.68 | 87.90 | ...... | 73.5 |
| | 5th. " | ..... | .50 | .90 | 1.63 | 2.89 | 6.23 | 15.68 | 37.71 | 52.85 | 68.96 | 81.30 | 87.78 | ...... | 75.6 |
| (Lawson's) Brockville | Green sand | ..... | ..... | ..... | ..... | .09 | .24 | .46 | .69 | 1.63 | 8.85 | 49.95 | 77.21 | ...... | 132.9 |
| | 1st. Burn | ..... | ..... | ..... | .05 | .18 | .46 | .75 | 1.22 | 2.79 | 11.56 | 48.43 | 74.05 | ...... | 134.0 |
| | 3rd. " | ..... | ..... | ..... | .13 | .26 | .44 | .81 | 1.21 | 2.31 | 10.41 | 51.75 | 77.06 | ...... | 131.3 |
| | 4th. " | ..... | ..... | ..... | .11 | .38 | .69 | 1:95 | 1.42 | 2.87 | 11.44 | 46.25 | 72.39 | ...... | 135.8 |
| | 5th. " | ..... | ..... | ..... | .18 | .38 | .68 | 1.16 | 1.93 | 3.91 | 12.83 | 50.46 | 72.91 | ...... | 132.7 |
| | 7th. " | ..... | ..... | .20 | .40 | .62 | 1.02 | 1.42 | 3.37 | 4.22 | 11.71 | 49.06 | 60.75 | ...... | 140.1 |
| No. 0 Albany Lawson's | Green sand | ..... | ..... | .14 | .46 | .88 | 1.38 | 2.03 | 3.01 | 5.03 | 11.27 | 19.46 | 26.64 | ...... | 171.4 |

**TABLE II.**

**Transverse Strength in Lbs.**
(500 grams sand used in all tests; therefore, percentages of water used is double number of cc's. used divided by 10).

| | $H^2O$ used. | 45 cc. | 50 cc. | 55 cc. | 60 cc. | 65 cc. | 77 cc. | 75 cc. | 80 cc. | 85 cc. | 90 cc. | 95 cc. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brockville, Fleck's | Green sand. | .... | .... | .... | .... | .... | 0.76 | 0.85 | 0.87 | 0.96 | 0.97 | 1.01 | 0.93 |
| | 1st. Burn | .... | .... | .... | .... | .... | 0.75 | 0.84 | 0.90 | 0.97 | .... | .... | 0.865 |
| | 2nd. " | .... | .... | .... | .... | .... | 0.86 | 0.85 | 0.86 | 0.81 | .... | .... | 0.845 |
| | 3rd. " | .... | .... | .... | 0.80 | 0.87 | 0.89 | 0.90 | .... | .... | .... | .... | 0.865 |
| | 4th " | .... | .... | .... | 0.76 | 0.75 | 0.65 | 0.85 | .... | .... | .... | .... | 0.752 |
| | 5th " | .... | .... | .... | 0.76 | 0.78 | 0.74 | 0.79 | .... | .... | .... | .... | 0.767 |
| No. 3 Albany Fleck's | Green sand. | .... | 0.74 | 0.73 | 0.93 | 1.07 | .... | .... | .... | .... | .... | .... | 0.867 |
| | 1st Burn | .... | 0.62 | 0.71 | 0.57 | .... | .... | .... | .... | .... | .... | .... | 0.633 |
| | 2nd. " | .... | 0.57 | 0.69 | 0.65 | 0.74 | .... | .... | .... | .... | .... | .... | 0.665 |
| | 3rd. " | .... | 0.65 | 0.65 | 0.80 | .... | .... | .... | .... | .... | .... | .... | 0.700 |
| | 4th. " | .... | 0.62 | 0.63 | 0.62 | .... | .... | .... | .... | .... | .... | .... | 0.623 |
| | 5th " | .... | 0.58 | 0.59 | 0.55 | .... | .... | .... | .... | .... | .... | .... | 0.573 |
| Brockville, Lawson's | Green sand. | .... | .... | .... | .... | .... | 0.76 | 0.85 | 0.87 | 0.96 | 0.97 | 1.01 | 0.903 |
| | 1st. Burn | .... | .... | .... | .... | .... | 0.84 | 0.76 | 0.84 | 0.89 | 0.95 | .... | 0.856 |
| | 3rd. " | .... | .... | .... | .... | .... | 0.92 | 0.97 | 0.96 | 0.85 | .... | .... | 0.875 |
| | 4th. " | .... | .... | .... | .... | .... | 0.90 | 0.92 | 0.88 | 0.88 | 0.85 | .... | 0.886 |
| | 5th. " | .... | .... | .... | .... | .... | 0.91 | 0.82 | 0.97 | 0.88 | .... | .... | 0.895 |
| | 7th. " | .... | .... | .... | .... | .... | 0.85 | 0.81 | 0.84 | 0.89 | .... | .... | 0.847 |

**TABLE III.**
**Permeability Test.**

Time in seconds. Gas Pressure=2.8 inches.

| | | 1st. Trial. | 2nd Trial. | 3rd Trial. | Average. | |
|---|---|---|---|---|---|---|
| No. 3 Albany Foundry Lawson's | Fresh | 4 1-5 | 5 | 4 | 4 2-5 | 60 cc. water used=12%. |
| | 1st. Burn | 4 | 3 | 3 1-5 | 3 2-5 | |
| | 2nd. " | 2 4-5 | 2 4-5 | 2 4-5 | 2 4-5 | |
| | 3rd. " | 2 4-5 | 2 4-5 | 2 4-5 | 2 4-5 | |
| | 4th. " | 3 | 3 1-5 | 2 1-5 | 2 4-5 | |
| | 5th. " | 2 3-5 | 2 3-5 | 2 3-5 | 2 3-5 | |
| Brockville Sand, Fleck's Foundry | Fresh | 19 | 17 3-5 | 18 | 18 1-5 | 70 cc. water used=14%. |
| | 1st. Burn | 8 | 7 3-5 | 8 2-5 | 8 | |
| | 2nd " | 8 | 8 | 9 1-5 | 8 2-5 | |
| | 3rd. " | 5 | 6 | 7 | 6 | |
| | 4th. " | 7 | 5 1-5 | 5 1-5 | 5 4-5 | |
| | 5th. " | 5 1-5 | 6 | 6 3-5 | 5 1-5 | |
| Fleck's Foundry Brockville Sand, | Fresh | 19 | 17 3-5 | 18 | 18 1-5 | 77 cc. water used=14%. |
| | 1st. Burn | 10 2-5 | 10 | 10 2-5 | 10 1-5 | |
| | 3rd. " | 12 3-5 | 10 1-5 | 11 | 11 1-5 | |
| | 4th " | 8 1-5 | 8 | 8 1-5 | 8 1-5 | |
| | 5th. " | 11 | 11 4-5 | 10 4-5 | 10 4-5 | |
| | 7th " | 8 4-5 | 7 3-5 | 6 4-5 | 7 4-5 | |
| Albany No. 0 | Fresh | 23 | 23 | 21 3-5 | 22 3-5 | 70 cc. water used=14%. |

# 'Nicu' Steel and its Manufacture

By G. M. COLVOCORESSES, Humboldt, Arizona.

(Read before the Montreal Metallurgical Association, April, 1918.)

In 1916 the world's production of nickel was 50,000 tons. Of this 85% was derived from ores mined in the Sudbury District of Ontario, such ores being essentially a combination of nickel, copper, iron, and sulphur, containing on the average 65 pounds of nickel, 34 pounds of copper and 800 pounds of iron per ton; 75% of all the nickel recovered was used in the form of nickel-steel with an average composition of 3.0% nickel, 96.0% iron. In this manner approximately 37,500 tons of pure nickel found employment. The iron contents of the nickel ores mined in the Sudbury district during 1916 amounted to 650,000 tons, all of which was slagged off and thrown away during the process of smelting and refining. During the same year in the production of a finished product of alloy-steel some 800,000 tons of iron had to be drawn from other sources. The market value of the iron contents of the nickel ores mined in 1916 would be approximately $14,000,000 at the average prices for that year, or twice that amount at 1917 quotations.

Such metallurgical practice is not conservation; it is not economic or ideal metallurgy, and the author will endeavor to prove that it will not be the practice of the future. In 1888, when mining and smelting operations were started at Sudbury the ores were mined for their copper values, because it happened that in the particular mines which were first opened the percentage of nickel, and the value of the nickel was considered very problematical. These ores were accordingly treated by a process which was based on the metallurgy of copper and which, with some slight modifications, has been in use ever since.

The ore that was mined in 1916 contained on the average: 3.25% nickel; 1.70% copper; 40.0% iron; 25.0% sulphur; 20.0% silica; and 10.0% alumina, lime, and magnesia. This ore was first roasted, mainly in open heaps, where the iron, nickel, and copper-sulphides were partially converted into oxides and the sulphur reduced to an average of about 10%. The roasted ore together with some green ore and flux was then smelted to a matte in blast or reverberatory furnaces. This matte, on the average, contained: 25.0% combined nickel and copper; 45.0% iron, and 25.0% sulphur. It was bessemerised like copper matte until the composition was approximately 80.0% combined nickel and copper, 1.0% iron, and 19.0% sulphur. The high-grade matte was then exported for subsequent refining and separation of the nickel and copper by either the Orford or the Mond processes. Both of these processes, which are complicated and expensive, result in a separation of the nickel and copper and the production of nickel or nickel oxide and copper or copper sulphate as may be desired. Three-quarters of the nickel product was subsequently combined with iron mostly in open hearth furnaces, and eventually converted into nickel-steel; while the copper was used for various purposes for which this metal is suitable.

The British America Nickel Corporation, which will shortly start smelting operations, intends to follow the same methods until bessemer matte is obtained, and will then separate the nickel from the copper by roasting, leaching, and electrolysis.

By all the present methods, the operators aim to save in one form or another as much of the nickel and copper as possible, but they absolutely and deliberately throw away all of the iron and all of the sulphur as well as the insoluble content of the ore. The mechanical and metallurgical losses, moreover, amount to about 20% of the nickel and 17% of the copper in the original ore.

Assuming that this year the value of iron is $30 per ton, the value of nickel 40 cents per pound, copper 25 cents per pound and sulphur (in medium grades of sulphuric acid two cents per pound, then in round figures, the 1,600,000 tons of ore which should be mined in the Sudbury district in 1918 will have a gross value in nickel of $41,500,000, of which $33,000,000 will be saved and $8,500,000 will be lost. The copper will have a gross value of $13,500,000, of which $11,000,000 will be saved and $2,500,000 will be lost. The iron will have a gross value of $19,000,000 which will all be lost and the sulphur will have a gross value of $16,000,000 which will be lost. So the gross value of the useful metals in the Sudbury ore production for this year will amount to a total of $90,000,000, of which $44,000,000 will be saved and $46,000,000, or 51%, will be lost. In passing it may be mentioned that the value of the precious metals in this ore will be about $800,000, of which approximately 33% is recovered by present methods. The figures given above are all gross: the net value of any metal or product is, of course, the difference between the actual sale price and the cost of production. If by new methods the cost of recovering the iron, sulphur, nickel, and copper now lost equals the actual market value of the products so saved, obviously the advantage from a commercial standpoint is nil; but the author contends that a large part of these lost metals can be recovered at a cost which will admit of a satisfactory profit and, if this contention is demonstrable, the question may pertinently be asked whether or not Canada can afford to waste annually such a quantity of her resources, valuable at all times, but now doubly so in time of war when every nerve must be strained to out-general the enemy not only on the field of battle but also in the field of industrial efficiency.

When, about the year 1890, the first matte from Sudbury was sent to the Orford Copper Works, it was treated by a process that provided for the recovery of the iron as well as the nickel and copper, but for certain reasons this process was not satisfactory; and with the development of the present Orford or 'salt-cake' process for separating the nickel and copper, the old method was discarded, and thereafter the iron in the matte was slagged off and lost. So the Sudbury ores have nearly always been treated like copper ores up to a certain point, being roasted, matted and bessemerised like copper ores, though the latter stages are different since it is necessary to separate the nickel from the copper by methods of treatment which have been developed and perfected over a period of 30 years and which have proved successful and profitable. Nevertheless the author claims that the entire present system of treating the Sudbury ore is wrong. Since this ore is essentially an ore of iron rather than an ore of nickel and copper, it should be treated as an iron ore; particularly since the nickel in large proportion must eventually return to a combination with iron, in which form it will actually be used, and because we now believe that the copper may also be used to some extent in combination with the iron quite as advantageously as the nickel.

In 1901 and 1902, the metallurgists of the Lake Superior Corporation (operating at the 'Soo') undertook to apply a radically different method of treatment of the Sudbury ore. They found that some of the ore contained a high percentage of nickel but very little copper, and by utilizing ore of this character (6% nickel and 1% copper) and partly separating such copper, they sought to produce directly a ferro-nickel. Their work was not a commercial success, principally because they could not satisfactorily separate the copper from the nickel, but they had at least an idea which was worth something and to Mr. Sjostedt and Mr. Ulke great credit is due for having started out to make a real improvement in the metallurgy of the Sudbury ores. At this time the author was employed by the Canadian branch of the Orford Copper Co., which was re-treating the blast furnace matte produced by the Canadian Copper Co., and raising it to a 72% (combined nickel and copper) matte for subsequent shipment to the Orford Works in New Jersey, and he was deeply interested in the process from a theoretical standpoint and thought that some method which could recover and utilise the iron in the Sudbury ore would eventually be developed and generally adopted.

The author had later an opportunity to learn something of the metallurgy of the garnierite ore in New Caledonia, which was being mined and exported to France, England, and the United States. Garnierite is essentially a hydrous-silicate of nickel and magnesia in a gangue of serpentine rock and the average composition of the ore as mined may be given as follows:—

| | |
|---|---|
| Water (uncombined) | 20% |
| Water (combined) | 10% |
| Nickel | 5% |
| Iron | 10% |
| Silica | 33% |
| Magnesia | 15% |

The nickel and iron both occur as oxides and there is also from 1% to 3% of lime and maganese, and less than 1% of cobalt and chrome. Like the Sudbury ore, the New Caledonia ore has nearly always been treated like an ore of copper. It contains no sulphur, but sulphurous material (generally gypsum or iron pyrites) is smelted with it to form a matte which is roasted, reduced, and refined repeatedly until impure nickel results. In 1880 a different process was tried in New Caledonia: the ore was smelted in a cupola or blast furnace to a 'fonte' or ferro-nickel, which was in fact an impure nickel pig containing 66% nickel and 24% iron; but this process did not succeed, partly because of the small scale on which it was operated, of the lack of skill on the part of the operators, of the general difficulties attending smelting in New Caledonia, and of the expense of removing the small percentage of sulphur which was transferred to the 'fonte' from the impure coke used in the blast furnace. The New Caledonia nickel ore contains only 10% or iron, but there exist on that island great deposits of hematite which contain 40% or 50% of iron with up to 0.5% of nickel, and which can be mined very cheap,

ly; there are also enormous deposits of coral limestone available for flux, and to-day, when we know more about smelting iron than they did in 1880, it seems logical that the New Caledonia nickel ore should be smelted with the iron ore and reduced directly to alloy-pig, and subsequently refined to alloy-steel without passing through the matting stage and the long series of subsequent treatments.

Except for a short run with an electric furnace in 1907, the New Caledonia ore has never been treated in this manner, since the failure of the old operations, but it may be interesting to note that in another part of the world a considerable amount of the New Caledonia ore has recently been smelted with iron ores from other sources and the nickel-steel produced is said to be of the highest quality and in every respect satisfactory, and as soon as the present war is over and freight conditions return to normal, it is probable that large quantities of New Caledonia ore will again be shipped for treatment in this manner.

It is my opinion that if New Caledonia is to continue in competition with Canada as a producer of nickel, the present method of treating the New Caledonia ores will have to be superseded largely by this manufacture of nickel-steel by direct smelting of the nickel ore with iron ore; but in this competition Canada will still have a great advantage, since the percentage of iron in the Canadian nickel ore is four times the percentage in the nickel ores of New Caledonia. True there is no sulphur in the New Caledonia ore, but I believe that sulphur in the Canadian ore can be roasted out with actual profit rather than with loss. The absence of copper from the New Caledonia ore may be considered an advantage, but the author hopes to prove that the copper in the Canadian ore is just as valuable as so much nickel, although elsewhere copper is only worth half as much per pound. All other conditions, moreover strongly favour Canada as against its distant but by no means negligible competitor.

In 1905 experiments were made by the late Major R. G. Leckie and my good friend and associate Harry A. Morin, on the smelting of the Sudbury slag for the production of iron, and in some respects their work was the forerunner of our present process for the treatment of slags. Shortly after, experiments on smelting the nickel ores in an electric furnace were again undertaken at the 'Soo' under the direction of Dr. Haanel and Mr. Sjostedt and some cupro-nickel pig iron was produced; but if I am rightly informed, they did not follow up this work because of the difficulty of separating the copper minerals from the nickel minerals and their belief that it was necessary to make such separation before a valuable alloy-steel could be produced. About this time the author was connected with a company which owned some deposits of impure iron in another section of Canada and in studying possible methods for the treatment of these ores he first made practical acquaintance with the electric furnace and realised the possibilities that electro-metallurgy was opening up for the iron and steel industry and for the treatment of impure and complex material. In 1908 the author visited Mayari, in the eastern section of Cuba, where a limonite ore containing a little nickel and chrome was being mined and treated by roasting and sintering and, after shipment to the United States, by smelting to a pig which was eventually refined (with the removal of the greater part of the chromium) to produce the 'Mayari Steel' now well known in commerce. This steel is really a ternary-alloy, a nickel-chrome-steel, the percentage of nickel being about 1.40, and the chrome being kept below 0.5%.

Since 1901 the author kept in mind the possibilities of treating the Sudbury ore as an iron ore rather than as a copper ore, and of smelting it to a pig rather than to matte. The development of the multiple hearth roasting furnace provided a means of desulphurising the ore as far as might be desired and at a comparatively small expense, and the development of the electric furnace provided a means of further reducing the sulphur in the calcined ore during smelting and refining to a point far below that required by the specifications for high-grade steels. The copper, however, still remained a stumbling block and to all intents and purposes rendered it impossible to determine how the ore could successfully be treated in this manner, because no process so far discovered could make a satisfactory commercial separation of the copper sulphides from the nickel and iron sulphides in the ore; yet if one admitted that the presence of copper was harmful to steel and particularly to high-grade steel, it was absolutely necessary that some means should be devised for making this separation before proceeding with the smelting and refining.

Developments in iron industries were, however, progressing rapidly and metallurgists were more and more frequently inquiring as to the real effect of copper in steel and the basis of the prejudice which existed on this subject. In 1909 Prof. Burgess with Mr. Ashton experimented at the University of Wisconsin on alloys of iron, nickel, and copper and came to the conclusion that when pure iron, nickel, and copper were mixed in certain proportions and if care was taken to avoid too high a proportion of carbon, the copper was not detrimental to the resultant product but appeared to replace a certain amount of nickel and to affect the steel in a similar manner. Mr. Clamer, of Philadelphia, was also experimenting along the same lines, and obtaining similar results, his work being practical as well as theoretical; and his conclusions were summarised in an excellent paper entitled "Cupro-Nickel Steel," which was presented to the American Society of Testing Materials in 1910. Mr. Clamer took out several patents for the cupro-nickel steel which he manufactured, and for a process for the manufacture of such steel, consisting in the treatment of matte by roasting and smelting with iron ores for the production of alloy-pig which was subsequently refined to steel. This process was a long step in advance, since Clamer kept the nickel and copper in combination and also kept a part of the iron, which had occurred in the ore in combination with the nickel and copper, in his finished product; but he still followed the original system of partly desulphurising the ore and matting, and in so doing a large part of the original iron was slagged off and lost.

Meanwhile, the International Nickel Co. had developed Monel metal, a natural alloy of nickel and copper, containing about 70% of the former and 27% of the latter, with a little iron and other impurities, and although this metal was developed mainly to provide a substitute for bronze and in some measure as a cheaper substitute for nickel, some clever people in the United States seized upon the opportunity to purchase Monel metal scrap as fast as they could, and to make with this Monel metal an alloy-steel, which they

passed off as nickel-steel, and which in practice was found to be about as good as nickel-steel. Actually, this Monel metal steel which was in effect a nickel-copper steel passed all the tests of the United States Government, and entered into the manufacture of a large number of armour piercing shells, and was also utilised to a considerable extent for automobiles and in other industrial lines of manufacture requiring a high-grade alloy-steel. The author believes that the Monel metal steel met the requirements of the manufacturers and users as well as the nickel-steel which it replaced at a considerably lower cost.

These developments had changed the whole outlook as far as the manufacture of alloy-steel was concerned, for they had practically proved that nickel and copper might be combined to form an allow steel without any disastrous effects resulting from the presence of the copper, and if Monel metal, representing the combined nickel and copper in the Sudbury ores, might be mixed with outside iron to form an excellent alloy-steel, why would it not be possible to retain with the nickel and copper the iron originally combined with them by nature and to manufacture therefrom a steel that would be equally good? In fact, the Sudbury ore became no longer valuable only for its nickel-copper content, but also for its iron, and it was a very valuable alloy-iron ore containing three metals, which might be kept in combination throughout the entire process and eventually turned into a valuable alloy-steel.

The author's old ideas, notes and experiments in Canada, New Caledonia, Cuba, and elsewhere were therefore reconsidered, seeking a practical method of treating the Sudbury ore. The result was a process for the direct manufacture of nickel-copper alloy-steel from the Sudbury ores and from the blast furnace slags which had been made in that district, and for the production of an alloy-steel which we now call by the trade name of 'Nicu Steel' and which has been manufactured in laboratories and on a small scale at intervals during the past five years, and under commercial conditions for the fire time in East Montreal during the fall of 1917.

Our process in principle is very simple. The treatment of the ore is based upon the assumption that the Sudbury ores are primarily iron ores rather than nickel-copper ores and that the ternary alloy which has been formed by nature in these ores is a valuable one for conversion into actual commercial use, providing the proportions of the three metals combined therein are properly regulated and the combination made complete and homogeneus. The 'Nicu' steel produced is, therefore, in reality a modified natural alloy, and we remove the main objection to natural alloys (which is the varying composition of the product) by so mixing the ores as to assure a practically uniform composition, and by adding during the process additional iron bearing material which will reduce in proportion the content of nickel and copper if this be higher than desired, or by mixing the ores with Sudbury slag in order to insure the same result.

The ore, as taken from the ground, contains 25% sulphur, which must be removed before it can be treated in a blast furnace or electric furnace: hence the first step in the process consists in crushing the ore to the necessary fineness (which we now find need not be less than 10 mesh) and in roasting it completely so that the resultant calcines shall not contain more than 0.50% sulphur; in practice we have been able easily to reduce this sulphur to 0.30%. The roasting, of course, requires some fuel, but not a great deal, since the ore, once ignited in a proper furnace, will roast itself down to 3% or 4% sulphur, and only requires fuel to drive off the balance of the sulphur. We believe that at some future time, when we are able to provide satisfactory equipment for carrying out this process on a large scale, the roasting will be carried on in multiple hearth roasters, and with such equipment the sulphur can be recovered at a profit and manufactured into sulphuric acid or possibly into elemental sulphur by the Hall or Thiogen process or some other process which may be developed later. I do not intend at present to dwell too much upon the value of the sulphur contained in the ore, because I do not yet know that it can be utilised with commercial profit, considering all the conditions of the industry. This is a subject which holds out great promise for the future, and which should be carefully studied, but it seems possible that a large percentage of the sulphur in the ore can be recovered in a useful form with profit to the operating company and with advantage to the Canadian industries which are employing sulphur, for which there is at the present time a considerable demand. In 1915, 46,000 tons of sulphur was imported into Canada and the imports at present must be far larger, yet 400,000 tons of sulphur are sent up annually in smoke from the Sudbury ores.

In the roasting furnace we shall probably plan to raise the temperature of the calcines in the lower hearth of the furnace to such a point that, when mixed with a proper binder, they will nodulise and be suitable for treatment in a blast furnace; thus rendering it unnecessary to employ electric furnaces for their reduction. Nodulising certain ores of iron in roasting furnaces or special kilns is an established practice, and there is no reason why it cannot be accomplished equally successfully in the treatment of the Sudbury ores.

After the ore is roasted we have practically an iron oxide ore which is hematite or in part magnetite and contains oxides of nickel and copper. The next step is the reduction of this ore, which may be carried out in an iron blast furnace using coke, or in an electric furnace using coke, coal, or charcoal for a reducing reagent. In any case, limestone must be added as a flux to slag off the silicates, as is usual in smelting iron ores. So far our actual operations have been carried on in electric furnaces only, since for obvious reasons it is not easy to start a process of this kind on the very large scale which the operation of a blast furnace involves, so that the data which I am now able to give are based upon the electric furnace practice. They seem sufficient, however, to point the way also to successful blast furnace operation. A theoretical comparison of the blast furnace with the electric furnace for the reduction of this ore has been made under many varying conditions, and although with very cheap electric power it may appear that the electric furnace would have some advantage over the coke fired blast furnace, still in practice it does not seem to work out this way, and for operating on a large scale the author is convinced that blast furnace treatment is preferable to treatment in the best type of electric furnace, although possibly in the future, conditions may change so as to give the electric furnace the advantage.

The product of the reducing furnace is an alloy pig containing iron, nickel and copper in the same relative

proportions as in the ore originally charged into the furnaces, or in such altered proportions as may have been brought about by the addition of other iron bearing material, and we are able to regulate the carbon as may be desired. Operating on a large scale we would plan to run the molten pig directly into a refining furnace, either an open hearth or electric furnace, or possibly some modified type of bessemer converter, and to turn the pig metal into steel, using a little lime to slag off the remaining sulphur, and reducing the carbon with hematite in the usual manner. In this portion of the process great care is required in order to make exactly the alloy-steel desired and to regulate the quantity of the nickel and copper which must enter into the finished steel.

Up to the present, not being equipped for continuous operation of the process, we have been obliged to allow the pig metal to cool and then to re-charge it into the refining furnace. At first an electric furnace was used for the steel making and good results were obtained except that the heats were comparatively small and required more time and expense than was desirable. Later, the pig metal was charged into an open hearth steel furnace of the ordinary type and was converted into open hearth alloy-steel with perfect success. The treatment of this nickel-copper pig iron in the open hearth furnace is entirely satisfactory, and in every way comparable to the treatment of ordinary pig iron, and it required no more time or expense to make the alloy-steel than is required for the production of ordinary carbon steel by the same method. The data we have gathered seem to show that if the preliminary roasting is carried sufficiently far, the blast furnace pig will not contain more than 0.2% sulphur, and this is well within the limits permissible for treatment in open hearth steel furnaces.

We are operating, of course, on a combination of three metals, instead of on a material containing only one metal, and we are treating these three metals as if they were one and carrying them in intimate combination from the start to the finish of the process. In doing this there are certain special considerations which have to be taken into account, and we have already learned some valuable practical points in connection with our operations, and will, no doubt, be able to improve the practice as we gain more experience.

The process which I have described above is also applicable, with a few modifications, to the blast furnace and reverberatory slags, of which there are some 8,000,000 tons now available in the Sudbury District, containing on the average, about 40.0% iron, 0.40% nickel, and 0.20% copper. This is an artificial iron ore with so little sulphur that it does not need to be roasted; it carries, however, a much lower percentage of nickel and copper than the natural ore and rather more copper than we desire in proportion to the nickel, and it is purely a question of commercial profit as to whether or not these slags can be utilized to advantage for the production of over 3,000,000 tons of alloy-steel. The steel which we have made from this slag is of excellent quality, but the nickel and copper contents are too low to make it a substitute for the standard 3% nickel steel, and it appears, therefore, that these slags can be treated in combination with the roasted ore, thereby obtaining from the mixture a steel which will carry about 3% of nickel and copper in the proportions of 3 or 4 to 1.

There are many ores in the Sudbury District which do not contain the correct percentages of nickel and copper for the manufacture of 'Nicu' steel; in some cases the copper content is more than half the nickel content and in a few cases the copper is as much, or even more than the nickel. In the arts and industries, however, a large amount of nickel will always be needed for other purposes than steel making. At present, about one-quarter of the entire nickel production is used for such purposes. Some of the nickel and copper becomes 'Monel metal' which has many important uses; some of the nickel is used in making bronze, or for the manufacture of 'German silver'; some is used for coinage (either pure or alloyed with copper) and some for nickel plating where a very pure nickel is required. Thus even if the 'Nicu' process should find general adoption, there would still be room for the treatment of ores which did not carry the correct percentages of nickel and copper, and which would naturally be treated along the lines of the present metallurgical processes for the production of pure nickel, pure copper, or Monel metal. Even in the treatment of these ores the 'Nicu' process can serve as a valuable adjunct by treating the slags from the blast furnaces in combination with other ores for the manufacture of 'Nicu' steel, and in this way there would be practically no loss of nickel, copper or iron from any of the ores.

The processes here described are covered by patents both in the United States and Canada, and these patents are now owned by the Nicu Steel Corporation, Limited. Without recounting the numerous laboratory experiments and trail runs which have been made in the past, a brief account may now be given of the actual manufacture of steel under commercial conditions as recently carried on in East Montreal. Not wishing to go to the expense of opening up a mine prior to testing out the process, we purchased from the Algoma Steel Company, a quantity of low-grade ore which had been mined some 20 years ago, and had been weathering ever since with the result that a considerable amount of the nickel and copper had been leached out, most of the sulphur had oxidised, and the ore had disintegrated to such an extent that it was almost a powder and did not require any crushing prior to roasting.

The average composition of the ore as received in Montreal was as follows:—Iron, 46.0%; nickel, 1.30%; copper, 0.28%; silica, 19.0%; and sulphur, 8.0%. The ore was roasted in an improvised reverberatory furnace which had formerly been used for heating steel shells, rabbling was done by hand, coal was used as fuel, and without any great difficulty the sulphur was reduced to an average of 0.40%. The calcined ore was charged into an electric tilting furnace of the Heroult type with three vertical electrodes and a rated capacity of 6 tons of steel. This furnace was not ideal for the reduction of the ore, but no other was available, and everything considered, it served our purpose very well. The average furnace charge contained: 1400 lb. roasted ore; 525 lb. burnt lime; 375 lb. coke breeze or coal, and some steel filings were thrown in on top of the charge to start the electric current. After heating for a short time, another charge would be added until six or eight charges had been added. Unfortunately, a considerable amount of iron was also picked up from the bottom and sides of the furnace which had been used for a long time previously for making pig iron from scrap steel. Slag was poured off at intervals

through the charging door by tilting the furnace, and the pig metal was poured from the opposite or tapping end of the furnace into a ladle and cast into slabs in the usual manner. The average composition of the pig was as follows:

| | |
|---|---|
| Nickel | 2.20% |
| Copper | 0.40% |
| Manganese | 0.18% |
| Silicon | 1.75% |
| Carbon | 3.0 % |
| Sulphur | 0.09% |
| Phosphorus | 0.07% |
| Iron (by difference) | 92.41% |

The slag produced from smelting the ore to pig metal contained 2.20% of iron and only a trace of nickel and copper, but in commercial practice it is safe to say that the iron content of the slag could be kept well below 1.0%.

The pig metal was subsequently refined, at first in the same electric furnace which had been used for the reduction of the ore, and afterwards with better success in an open hearth furnace of standard type and following closely the practice of ordinary steel making. The average composition of the steel resulting therefrom was as follows:

| | % |
|---|---|
| Nickel | 2.13 |
| Copper | 0.40 |
| Carbon | 0.20 |
| Manganese | 0.51 |
| Sulphur | 0.03 |
| Silicon | 0.03 |
| Phosphorus | 0.006 |
| Iron (by difference) | 96.694 |

The slag obtained from the dumps at Copper Cliff was treated in nearly the same manner as described above, but without preliminary roasting and with slight modification of the flux. This slag had the following composition:

| | % |
|---|---|
| Nickel | 0.45 |
| Copper | 0.30 |
| Iron | 46.14 |
| Sulphur | 2.20 |
| Silica | 22.30 |
| Alumina, Lime & Magnesia | 20.0 |

The steel, resulting from the reduction of the slag to pig metal and the subsequent refining in the open hearth furnace had the following analysis, and it will be noted that the percentage of nickel was increased in proportion to the percentage of copper, presumably by 'salting' from the furnace, which had just been used for the treatment of the higher nickel pig made from the ore:

| | % |
|---|---|
| Nickel | 1.33 |
| Copper | 0.46 |
| Carbon | 0.34 |
| Manganese | 0.63 |
| Sulphur | 0.041 |
| Phosphorus | 0.017 |
| Silicon | 0.019 |
| Iron (by difference) | 97.163 |

During the trial operations above described, about 72 tons of steel were made from the ore and about 18 tons of steel from the slag. The steel is now being put to various commercial uses, while test pieces taken from the various heats have been submitted to physical tests, and similar samples have been submitted to the proper authorities and Commissions in both the United States and Canada to be tested out for military purposes. The results of some of the tests which were performed on our behalf, are given below and for comparison are added the composition and requirements adopted by the British Government for automobile steel containing approximately the same percentage of nickel as the combined nickel and copper content of the 'Nicu' Steel.

| **British Government Standard.** | **Nicu Steel.** |
|---|---|
| (E.S.C. 2% nickel case-hardening Steel.) | |
| Ontario Nickel Commission Report, p. 360. | |
| Analysis— | |
| Carbon . . . . . 0.10—0.15% | Carbon . . . . . . . . . . 0.20% |
| Managanese. . . 0.25—0.50% | Manganese . . . . . . . 0.51% |
| Sulphur. . .. not over 0.05% | Sulphur . . . . . . . . . 0.03% |
| Phosphorus not over 0.05% | Phosphorus . . . . . . . 0.006% |
| Nickel . . . . . . . . 2.0—2.5% | Nickel . . . . . . . . . . 2.13% } |
| | Copper . . . . . . . . . . 0.40% } |

**Physical Tests.**

| | |
|---|---|
| Tensile . . . . (tons) 25 to 35 | Tensile . . . . . . .(tons) 31 |
| Yield Point not less than 55% | Yield Point . . . . . . . 74.5% |
| Elongation not less than 30% | Elongation . . . . . . . . 35% |
| Reduction not less than 45% | Reduction . . . . . . . . 62.6% |
| Normalised at 850°C. to 900°C. | Forged natural. |

I also quote as follows, tests on various heats of the 'Nicu' steel produced and subjected to heat treatments as noted.

**Nicu Steel Corporation, Ltd.**

Tests on 'Nicu' Steel.

| | Tensile lb. per sq. in. | Yield lb. per sq. in. | Elongation. 2″ % | Reduction. % |
|---|---|---|---|---|
| Forged . . . . . . . . . . .Heat 1 | 69,440 | 52,192 | 35. | 62.6 |
| Natural . . . . . . . . . . .Heat 4 | 67,648 | 50,848 | 35. | 62.6 |
| Heated to 1425° F. | | | | |
| cooled with air . . . .Heat 1 | 69,440 | 58,240 | 31. | 55. |
| " " " Heat 4 | 70,560 | 58,240 | 30.5 | 55. |
| Heated to 1450° F. | | | | |
| Quenched in oil and | | | | |
| re-heated to 800°F. .Heat 1 | 72,800 | 53,760 | 34. | 55.5 |
| " " " Heat 4 | 75,712 | 58,688 | 35. | 55. |
| Heated to 1550° F. | | | | |
| Quenched in water and | | | | |
| re-heated to 600°F. .Heat 1 | 85,120 | 64,288 | 28. | 55 |
| " " " Heat 4 | 84,670 | 69,440 | 28. | 55. |

Chemical analyses—

| | Carbon. | Silicon. | Sulphur. | Phosphorus. | Manganese. | Nickel. | Copper. |
|---|---|---|---|---|---|---|---|
| Heat 1 | 0.20% | 0.03% | 0.03% | 0.006% | 0.51% | 2.13% | 0.40% |
| Heat 4 | 0.28% | 0.014% | 0.038% | 0.005% | 0.58% | 2.16% | 0.41% |

Nicu steel produced commercially at the Canada Cement Co. steel plant, East Montreal, and tested by Dr. Alfred Stansfield. In comparison with nickel-steel of similar composition as given in tabulated form on Page 387 and Page 416 Royal Ontario Nickel Commission Report:

| | 'Nicu' Steel. Heat No. 6. | Nickel Steel. Page 387. | Nickel Steel. Page 416. |
|---|---|---|---|
| Carbon | 0.37% | 0.47% | 0.47% |
| Manganese | 0.88% | 0.86% | . . . . . . |
| Nickel | 1.89 } | 2.15% | 2.92% |
| Copper | 0.37 } 2.26% | . . . . . . | . . . . . . |
| Yield Point | 52,000 lb. | 52,000 lb. | 56,000 lb. |
| Tensile Stress | 96,500 lb. | 93,000 lb. | 95,400 lb. |
| Elongation on 2″ | 24.3% | 24.5% | 22% |
| Reduction of Area | 50.8% | 51.8% | 44.6% |
| Bending Tests 180°. | Showing no crack. | Showing no crack. | |

Physical tests and analyses of 'Nicu' steel Heat No. 6 made by Dr. Alfred Stansfield of McGill University and comparison with nickel-steel as per specification for plates and shapes,

Ontario Nickel Commission Report, Page 365:

| | Natural 'Nicu' Steel. | Nickel Steel. |
|---|---|---|
| Carbon | 0.37% | 0.45% |
| Manganese | 0.88% | 0.70% |
| Phosphorus | 0.064% | 0.04% |
| Sulphur | 0.047% | 0.04% |
| Nickel | 1.89% } 2.26% | Nickel 3.25% |
| Copper | 0.37% | |
| Tensile Stress, lb. per sq. in. | 96,300 | 85,000 to 100,000 |
| Yield Point, lb. per sq. in. | 56,350 | 50,000 |
| Elongation on 9 in. | 18.7% | 16.2% |
| Reduction of Area | 36.3% | 25.% |

Nickel Steel Specification in connection with the fabrication of the large bridge to span the Mississippi River at Memphis:

| | |
|---|---|
| Tensile Strength | 85,000—100,000 lbs. |
| Elastic Limit not less than | 50,000 lbs. |
| Elongation in 8 inches not less than | 1,600,000 / Tensile Strength. Av'ge 17% |
| Reduction of Area not less than | 30% |

Results of the Royal Ontario Nickel Commission, Page 415, Table 3, from 'Nicu' Steel and nickel-steel produced under exactly the same conditions during their investigation of the Colvocoresses process:

| | 'Nicu' Steel Heat. No. 2. | Nickel Steel Heat No. 4. | 'Nicu' Steel Heat No. 6. |
|---|---|---|---|
| Carbon | 0.43% | 0.53% | 0.53% |
| Nickel | 2.10% } 3.30% | 3.43% | 2.45% } 3.25% |
| Copper | 1.20% | None | 0.80% |
| Elastic Limit | 82,600 lb. | 77,400 lb. | 80,000 lb. |
| Tensile Strength | 110,400 lb. | 115,400 lb. | 111,600 lb. |
| Elongation on 2″ | 22% | 20% | 19.1% |
| Reduction of Area | 48% | 38.3% | 38.3% |

These steels were produced under the direct supervision of Geo. A. Guess, Professor of Metallurgy University of Toronto, in conjunction with the Royal Ontario Nickel Commission.

The following are extracts from Prof. Guess' Report:—

"It is evident from the results in Table 3, that these laboratory-made steels are of good quality."

"The value of this process of producing nickel-copper steel is based on the belief that copper may replace a very considerable amount of the nickel in a 3.5 per cent nickel-steel, without producing an inferior article, which belief is, I think, well founded."

Tabulated data compiled from various sources by H. A. Morin of Nicu Steel Corporation, Ltd.

| | Analyses of Commercial Nickel. | Analyses of Average Monel Metal. |
|---|---|---|
| Nickel | 99.10% | 68.30% |
| Copper | 0.03% | 27.53% |
| Cobalt | 0.40% | 0.47% |
| Iron | 0.30% | 2.18% |
| Carbon | 0.05% | 0.05% |
| Sulphur | 0.03% | 0.04% |
| Silicon | 0.05% | 0.20% |
| Manganese | 0.12% | 0.14% |

Physical Properties.

| | Rolled Nickel Natural. | Forged Nickel Natural. | Rolled Monel Metal Natural. |
|---|---|---|---|
| Elastic Limit | 21,045 lb. | 21,360 lb. | 55,587 lb. |
| Tensile Strength | 72,522 lb. | 72,128 lb. | 88,232 lb. |
| Elongation in 2″ | 43.9% | 45.5% | 42% |
| Reduction of Area | 29% | 57% | 55% |

| | Copper Plates as rolled. | Monel Metal Plates as rolled. |
|---|---|---|
| Elastic Limit | 18,000 lb. | 45,800 lb. |
| Tensile Strength | 34,000 lb. | 90,000 lb. |
| Elongation in 2″ | 52% | 30% |
| Reduction of Area | 57% | 60% |

The above figures show the physical properties of commercial nickel, pure copper, and a natural alloy of nickel-copper (Monel metal) manufactured by processes of concentration of the nickel-copper originally contained in the pyrrhotite ores of the Sudbury district.

While these results have been extensively published and are generally well known, I feel this comparison on the same page will prove of interest to show the superior physical properties of Monel metal over pure nickel and pure copper. This fact to my mind will serve to give further evidence that 3½% nickel-copper in like proportion added to steel will replace pure nickel in 3½% nickel-steel.

Royal Ontario Nickel Commission Report, Page 421. Comparison of 'Nicu' Steel, with nickel-steel:

| | 'Nicu' Steel. | Nickel Steel. |
|---|---|---|
| Carbon | 0.44% | 0.46% |
| Silicon | 0.034% | 0.066% |
| Manganese | 0.50% | 0.70% |
| Phosphorus | 0.013% | 0.021% |
| Sulphur | 0.013% | 0.034% |
| Nickel | 3.62% } 4.10% | 3.36% } 3.46% |
| Copper | 0.48% | 0.10% |
| The Physical Tests of the rolled natural steels showed:— | | |
| Elastic Limit | 72,400 lb. | 74,624 lb. |
| Ultimate Strength | 115,000 lb. | 122,000 lb. |
| Elongation in 2″ | 22% | 16% |
| Reduction of Area | 51% | 34% |
| In the annealed condition, the results were:— | | |
| Elastic Limit | 63,750 lb. | 64,750 lb. |
| Ultimate Strength | 107,300 lb. | 119,000 lb. |
| Elongation in 2″ | 25% | 17% |
| Reduction of Area | 48% | 37.5% |

The author has described the recent manufacture of steel in Montreal because it was the first 'Nicu' steel produced in a commercial manner by the 'Nicu' process, but the foregoing tables embody a number of tests conducted by different companies and individuals on 'Nicu' steel or the nickel-copper-steel, which, while similar in composition, was formerly made by different processes, and all of these tests, without exception, tend to prove that the 'Nicu' steel, or the nickel-copper-steel is just as good as the nickel-steel which we hope, in a measure, to replace. In 1916, Dr. Stansfield of McGill University, at the author's request, experimented with the 'Nicu' process and made some excellent steel, and a little later Professor Guess of Toronto, working under the direction of the Ontario Nickel Commission, also did valuable work along the same lines, and reports of their experiments, together with the tests made upon the steel produced, and on other similar steels, are embodied in the Report of the Royal Ontario Nickel Commission, which is altogether the most valuable treatise on nickel that has yet been published.

The author's experiments indicate that the best product is produced when the copper does not exceed one-third or one-quarter of the nickel contained in the finished product. In one experiment by the Ontario Government, a steel containing nearly equal amounts of nickel and copper showed up very nicely in the mechanical tests, but the author's experience with steel of approximately this composition had not been very satisfactory, and he would not recommend any 'Nicu' steel in which the copper is in excess of 40 per cent of the nickel, and would prefer a steel in which the copper was not more than 30 per cent of the nickel, moreover, the copper content should probably not exceed 1 per cent if the steel is to be used for the same purposes as nickel-steel. A great deal of nickel-steel as used at present contains 3 per cent nickel, and we have found 'Nicu' steel containing 2.25 per cent nickel and 0.75 per cent copper is in all re-

spects similar and equal to the nickel-steel mentioned.

The author will go a step further, and say that in some respects 'Nicu' steel is better than ordinary commercial nickel-steel, because it is a more homogeneous mixture and more uniform in composition. Nickel steel is made by adding nickel or nickel oxide to steel in the bath of the open-hearth furnace; thus the nickel is added in the final process of steel-making and is kept in combination with the iron, after melting, during a period of five or hix hours. The theory of alloys teaches us that the nickel forms a solid solution with the iron, but it is a question just how complete and how uniform this solution can be made, and the problem that has confronted steel makers has been to secure an alloy having a thoroughly uniform composition, and to prevent segregation in various parts of the resulting ingots. In the 'Nicu' process we calculate our charge and our alloy mixture before we smelt the ore into pig, and as far as possible the final percentage of nickel, copper and iron is arranged for by mixing the ores before any smelting takes place, or during the first stages of the smelting. The sulphides or oxides of the three metals are then combined at the very outset of our operations, and the pig metal contains these elements in approximately the same proportion as the finished steel; the nickel combining freely with both iron and copper and never releasing them throughout the entire process. Perhaps, in a blast furnace or a shaft electric furnace, there would be times when the composition of the metal might not be entirely uniform, but such a condition is rectified in the refining furnace. The final alloy-steel should therefore be of uniform composition and a more perfect mixture than ordinary alloy-steel made by the present methods, and so far as we have been able to determine this actually results from carrying out the 'Nicu' steel process. We feel that we have proved and are ready to prove again that 'Nicu' steel is a valuable alloy-steel; that it is not red-short or brittle, and that the copper contained in certain fixed percentages, relative to the nickel, acts just exactly like nickel and replaces the same quantity of a metal which normally sells for double its value. Aside from the mechanical qualities of the steel, there is every reason to believe that the addition of copper tends to render the alloy less subject to the action of acids, salt water, etc., and hence makes it especially valuable for shipbuilding, pump parts and numerous other uses.

Clamer experimented at considerable length on the effects of acids, salt air, and salt water on nickel-copper steel made from Monel metal and found its resistance most remarkable, while the beneficial effect of the addition of small quantities of copper to ordinary steel has been known for a long time and taken advantage of by steel-makers to make special brands of non-corrodible steel for roofing and similar purposes.

We do not yet know how 'Nicu' steel will behave when utilised for armour plates or for many of the more important purposes for which nickel-steel is now employed; but judging from the fact that Monel metal steel made excellent armour-piercing projectiles, we believe that a 'Nicu' steel armour-plate will be well worth trying out. We do not konw how it will behave when rolled into rails, but from tests which have been made for other purposes, there is every reason to think that 'Nicu' Steel rails will prove very useful and valuable, and if, as we claim, they can be manufactured at a cost only slightly greater than that of the ordinary steel rails, we think that there will be an immense demand in the future for 'Nicu' steel-rails wherever the wear is unusually severe. So much for the quality of our product which so far as tests have proven up to the present time we can truthfully say appear to be equal to nickel-steel, but we must admit that the final value of 'Nicu' steel can never be determined until it is actually put into commercial use and tested out for various purposes in the arts and industries.

Now, let us turn to the cost of manufacture, and here I must theorise somewhat since we have no actual experience from which to quote. Laboratory work, of course, has given no clue to actual manufacturing costs, and even our work in Montreal was carried on in a plant which could only be leased for a month for the purpose and where we operated under many handicaps and with many make-shift appliances, and the costs of our manufacture form but little better basis for calculations than the work previously done in the laboratory. Let us, however, start with the mining of the ore, and assuming that we already have an ore body, we know that the ores of the Sudbury District can be mined on the average for $3.00 per ton, this being about the average cost attained in 1916. The cost of crushing, roasting and sintering we can justly compare with the cost of similar operations on copper or iron ores and this may fairly be placed at an outside figure of $2.50 per ton. The roasted and sintered ore is practically in the same condition as an ordinary hematite iron though the iron contained is lower than the average in most ores which serve commercial uses to-day, and the smelting cost is, therefore, comparable to the cost of smelting iron ores in the same locality, and provided a blast furnace is utilised, and assuming that it will require two tons of Sudbury ore, plus a small amount of pig iron or scrap iron to produce one ton of pig metal, we figure liberally that our smelting costs will be about $12.00 per ton of pig, and the total cost of a ton of alloy pig will, therefore be $23.00. In the open hearth the pig metal may be made into steel for the same coast as ordinary pig iron is refined to steel by this process and our alloy-steel, allowing for general and overhead expense, therefore, would cost about $35.00 per ton. Now, if we mined an average grade of Sudbury ore, the results would be one ton of 'Nicu' steel, containing about 6 per cent nickel and about 2 per cent copper, which would be comparable to 8 per cent nickel-steel; the percentage of nickel and copper is higher than would be required for most commercial purposes and by mixing in the open hearth or in a blast furnace, the smelted ore with slag, or with ordinary pig iron, or scrap iron, the percentage of combined nickel and copper is reduced in reference to the iron, and the steel would contain about 2.25 per cent nickel and 0.75 per cent copper and would be equal to 3 per cent nickel-steel. The total cost of manufacturing this 3 per cent 'Nicu' steel figures as above at $30.00 per ton, assuming that slag is used and paid for at a reasonable price. The steel would cost $30.00 per ton if scrap iron were used and paid for at $16.00 per ton, or $40.00 per ton if pig iron were used and paid for at $30.00 per ton. These estimates may be compared with the selling price of 3 per cent nickel-steel, which at the present time is upwards of $100.00 per ton and which in normal times would be over $60.00 per ton. No account is taken in these calculations of the possible profit which might result

from the recovery of the sulphur and the sale of this valuable by-product.

The costs which I have given above will, I believe, stand careful analysing, although round figures have been used, and it is not my intention in this article to dwell at any great length upon the commercial aspects of this process. These, however, must be considered, since no prices or method of manufacture can be considered successful unless it actually produces a valueable product at a profit to the manufacturers. We do not, of course, yet know just what the costs will be when operations are carried out on a large scale, but it seems as if there were sufficient data to make a very fair and conservative estimate and, unless the author is sadly at fault in some particular, the proposition would appear attractive from the financial as well as the metallurgical side. There remains the fact that such a process can only be worked satisfactorily by a company possessing a large supply of suitable ore, and, moreover, that a very heavy investment for plant and equipment would have to be made before working conditions could be established and operations carried on with economy and efficiency. Such operations must be undertaken on a large scale which we believe will be amply justified by the large demand which should be established for a satisfactory substitute for nickel steel, sell at a price far lower than nickel-steel can be sold for at the present time. We have an iron mining and smelting proposition with the cost of ordinary steel making increased by the higher value of the ore in the ground, the higher cost of mining the Sudbury ore, the cost of roasting and crushing and sintering, and the increased cost of fluxing the larger percentage of insoluble matter. The operating costs of the blast furnace and the open hearth, or of the electric furnace if substituted for either or both of these, should be no greater than they are at present in ordinary steel practice, but instead of producing an ordinary steel we produce a high-grade alloy-steel which is far more valuable for many purposes than any ordinary steel; far superior in physical and mechanical qualities and commanding a price double that of ordinary steel, and this difference in price should amply compensate for the increased working costs enumerated above.

From the commercial standpoint, the claim is made that 'Nieu' steel is as good as nickel-steel and that the 'Nieu' process will enable the manufacturers to make such steel for a much lower price than nickel-steel can be made at the present time, and by the methods now in use, and considering the enormous demand for nickel-steel, and particularly the extra demand that would result from a material reduction in the price 'Nieu' steel should find an ample market without difficulty.

From the metallurgical standpoint, we claim attention as presenting a new alloy and a new method of manufacturing a ternary alloy and of treating an ore that has long constituted one of the most valuable resources of Canada.

From the standpoint of conservation, we offer a method that should provide for the profitable recovery and utilisation of the enormous amount of iron that is now thrown away in the Sudbury District, and perhaps also of all the sulphur which is at present wasted with no advantage to smelting companies and with more or less detriment to the agricultural industry of of the neighbourhood.

It seems reasonable also to assume that the adoption of this process will permit the profitable mining and treatment of large deposits of ores low in nickel and copper content, but comparatively high in iron, which deposits must otherwise remain unworked.

The 'Nieu' process will not provide a means of recovering the precious metals (gold, silver and the metals of the platinum group) occurring in the ore to the average value of 50 cents per ton (of which less than 40 per cent is saved by present methods), but it can save 98 per cent of the nickel against 80 per cent saved by the present methods; 98 per cent of the copper against 83 per cent saved at present; 96 per cent of the iron and probably 80 per cent of the sulphur, both of which are entirely lost at present. Turning back to the figures quoted at the beginning of this paper and assuming the gross value of the useful metals in the Sudbury 1918 production to be $90,000,000, I repeat that metals to the value of only $44,000,000 will be saved this year, whereas the general application of the 'Nieu' process for ore and slag would result in the saving of metals with a value of $41,000,000 additional, making a total recovery of 94 per cent against 49 per cent, and with a very comfortable profit to the operators.

From the industrial standpoint, we claim attention as presenting a method of establishing a valuable new industry in the Dominion of Canada; an industry which may produce annually close to 600,000 tons of high-grade alloy-steel, largely from material now thrown away, or nearly 40 per cent of the total steel produced in the Dominion at the present time, and a valuable alloy-metal which can be produced altogether or in great part in Canada, and which should fill an important place in the prosecution of the war, while after the war shall be happily and successfully ended, this alloy-metal should also be of continuous and equal value in the arts and industries of peace.

We are proposing something very radical,—to upset the established practice for the treatment of the Sudbury ores—a practice which is as old as the discovery of the ore bodies, which has been operated continuously and improved upon frequently, which has successfully accomplished its purpose and proved very remunerative to the operators. We are proposing to introduce into the industries a new alloy-metal to partly replace one of the most valuable and widely known alloys of steel; above all, we are proposing to run counter to the prejudice against copper in steel which is far older than the discovery of the Sudbury mines and which still persists in the mind of manufacturers and users of alloy-steel, in spite of the fact that repeated experiments and actual performance have proved this prejudice unfounded. We realise fully that it will be an uphill fight to firmly establish this new industry, but we feel that our process rests on a sound metallurgical and commercial basis, we feel encouraged with the progress which we have made and are very confident of our ultimate success, which will mean some very important changes in the mineral industry of Canada.

For the treatment of the many million tons of Sudbury ore still to be mined, we believe that our process alone will measure up to the standards of conservation and efficiency which are going to prevail in the future; for the most vital lesson of the present war is this: "The greatness of a nation does not consist in the possession of great natural resources, but in the efficient use which is made of them."

## B.C. SHIPBUILDING PLANT GUTTED BY FIRE.

### Large Portion of Plant and Equipment Burned.

The building of steel ships in Vancouver received a severe setback by a fire which on May 15 destroyed a large portion of the plant of J. Coghlan and Sons on False Creek. Robert Cameron, a fireman from No. 12 hall, was killed by the falling walls of the boiler shop, and a number of firemen were slightly injured. The damage done was estimated at between $1,500,000 and $1,750,000, and more than half of the company's 2,800 employees will be out of work. Reconstruction of the plant will require months of time, and the completion of the steel ships which were at the fitting-out wharf, will be greatly delayed. The engines of the steamer Alaska were destroyed with the boiler shop.

The yards had four ship ways, two of which had keels laid on them, and are entirely intact. No. 3 way, with the War Charger, was partly destroyed, and the Charger was subjected to tremendous heat, which warped some of the plates and caused other damage, but the injury to this ship is not beyond repair, and probably will be covered by $100,000. On the next way was the War Chariot, 75 per cent plated, which is a total loss. The supporting piles burned through, the foundations gave way and the ship settled down in the mud with her back broken. Salvage operations will be very acceptable. The entire plant was fully insured, including the ships under construction.

The fire started in the boiler room and gained great headway when the acetylene plant used for welding, exploded. As the fire spread and there was danger of the War Camp and the Alaska falling victims where they were moored, volunteers took them into tow, and hauled them into the stream to safety. The fitting out wharf, the boiler room, draughtsmen's quarters and various other departments were completely destroyed. Large quantities of material were consumed, and this will hamper operations until they can be replaced.

C. Williams, who is here from Glasgow, representing Raeburn, Veril, Limited, for whom the steamer War Chariot, War Charger, and other ships, were building, stated that, in his opinion, $2,000,000 would be a conservative estimate of the damage.

The equipment saved includes the moulding loft, the rolls, the punch shop, the blacksmith shop, the plate shop, and No. 1 and No. 2 building slips. On these slips are the keels of hulls, five and six, but these vessels have not reached an advanced stage, and after the debris has been cleared away and the plant organized, it will be possible to go on with construction.

The herring packing plant of Watson Bros., just east of the shipyards, was entirely consumed by this morning's fire. John E. Watson estimated the firm's loss at nearly $20,000, largely covered by insurance.

---

## SPIEGEL IS SOUGHT.

Cleveland, May 28. — A local steel-maker is inquiring for 500 tons of spiegeleisen for last half. A northern Ohio consumer in the week bought several hundred tons for similar delivery. Ferroalloy prices are unchanged.—From Trade Review.

---

It is stated that China has known iron ore deposits equal to about 402,000,000 tons. Of this the Government still retains about one-third.

## SCHWAB CONFIDENT OF SUFFICIENT SHIPS.

### Tells Steel Men This Government and Lloyd George Will Have Enough to Win War.

### RAPID STRIDES BEING MADE.

Points to increase of 300,000 Shipyard Workers Since Last January.

Confidence that the industrial needs of the war against Germany would be met was expressed by Chargles M. Schwab, General Manager of the Emergency Fleet Corporation, and J. Leonard Replogie, steel representative on the War Industries Board, who spoke at the annual dinner of the American Iron and Steel Institute at the Waldorf. "I am not going to make any predictions", said Mr. Schwab, "but I am sure that this Government and Lloyd George are going to have what they require—ships for the winning of the war.

"During the month of May, ending today, the United States produced — not launched, but put into commission, ready for service — 250,00 deadweight tons. And I am sure the month of May is going to be the least productive. I have enlisted the support of every industry in the shipbuilding or accessory line that is possible at this date; but that is not enough. During the past week we have contracted for new works aggregating $200,000,000 or $250,000,000 that will increase the shipbuilding capacity of the United States by at least 8,000,000 tons a year, and we will double that if necessary. We shall produce during this year 400,000 or 500,000 tons on the Great Lakes alone; but I think that is not enough, and in the coming year we can expect at least 1,000,000 tons from the Great Lakes.

**350,0000 Shipworkers.**

"Last January there were 60,000 workers in the shipyards of the country. Today there are 350,000, and another 350,000 in the engine, boiler, and accessory works.

"I am not vain enough to believe that any individual is a very great factor in so vast an undertaking. What is necessary is the united effort of everybody. Many people acquainted with the affairs at Washington are prone to criticise what has been done. I was of the same mind at one time, but in my opinion the work done at Washington by Mr. Hurley, Mr. Piez, General Goethals, and the men who have been at this job has been magnificent. When the war started practically every shipyard in the country was taken up by the navy. Every shipyard for the Emergency Fleet Corporation had to be created. I have already examined 60 or 70 per cent. of the shipbuilding capacity of the United States, and I want to say that the work has been magnificently accomplished.

"But I don't believe we at Washington are a very great factor after all. The men who have the real responsibility are those in direct charge of the shipbuilding yards and the accessories. We can do little more than grease the wheels of progress. But the task and the responsibility is on the men in the shipyards; and not only the managers but down through the superintendents and foremen to the workers themselves. And only by their working as a unit can the result be accomplished. Don't think we are not accomplishing anything, for we are. We have started the shipbuilding program at a pace that cannot be stopped.

"I am proud of the steel industry. I feel confident

that the steel industry will give us this year and next all the steel we need for carrying out the program. There is no industry anywhere that has so willingly and nobly and enthusiastically done its work for the country."

Mr. Replogle said that the direct and indirect necessities of the United States Government would require all that the steel mills could produce for this year at least.

"We have been giving a good deal of attention to the question of essential and non-essential industries," he said. "I was rather surprised to find that the corset industry uses 15,000 or 20,000 tons of high-grade steel annually, and they claim that this is a necessity. All industries are essential from some standpoint, that of of the owner if no other. We have preferred to go about it the other way and make a list of the more essential. How necessary this is you will see from the fact that we have unfilled orders on iron and steel manufacturers for the United States and the allied Governments for 16,800,000 tons. The burdens of the Allies are going to be much greater; the railroads will need many more rails, and Mr. Schwab's program next year will be double that of this year.

**Sleeves Up For the Flag.**

He praised Mr. Schwab, whose appointment, he said, was an epoch in the war, and the work done by Barnard M. Baruch at the head of the War Industries Board.

"Today", he said, "100 per cent. of the steel manufacturers are doing their utmost. There is not a single exception." He told of a poster put up by a Pennsylvania steel company which read:

"Not just hat off to the flag—sleeves up for it." This poster was spread about, he said, and as a result a coal mine manager in Johnstown had told him that the production had increased 10 per cent. the first week and men had come to his asking to be allowed to work overtime.

Ex-Congressman John J. Fitzgerald decried too much criticism of mistakes made by the Government. "A public servant who never makes any mistakes," he said, "is not likely to accomplish much."

Martin W. Littleton and Dr. Thomas Darlington also spoke. Dr. Darlington, who is Secretary of the Welfare Committee of the institute, urging the heads of steel companies to be as careful with their own health as they were with that of their employees and giving a set of rules for the benefit chiefly of men between fifty and seventy-five. Elbert H. Gary presided.

---

## GARY SAYS OUTLOOK FOR BUSINESS IS GOOD.

### Tells Steel Men This is a Time for Level Heads, Patience, and Patriotism.

An atmosphere of optimism surrounded the fourteenth general meeting of the American Iron and Steel Institute, which was held recently at the Waldorf-Astoria. Judge Elbert H. Gary, Chairman of the board of the United States Steel Corporation, and President of the Institute, sounded the keynote of the day's proceedings at the morning session when he said, "This is a time for judgment, for patience, for level heads, for patriotism, and above everything else, the grit that stands and fights and never gives up."

Judge Gary emphasized that the relations of the steel producers with the Government were most harmonious, thereby auguring well for the success of the great shipbuilding, ordnance, and other programs projected by the Government to carry the nation to final victory.

"On the whole," Judge Gary said, "our business is good. We at least have a steady customer, and one able to pay. Our prospects at the present time, notwithstanding the horrors and the cost of the war, are good. We have reason to be hopeful. The man who recognizes the dangers and the difficulties which are in sight is not necessarily a pessimist. I prefer the man who takes a broad vision, which covers possible disasters and possibilities of destruction, but puts his back up against the wall and, with his teeth shut, proposes to fight it out until success is achieved."

Judge Gary called attention to the fact that the Government was permitting, assisting, and urging the steel and iron industry to put the business in better shape. He said that day by day "we are putting our affairs in better shape," and added that the industry would be well prepared to succeed in the competition for international trade following the end of the war. "If we win the war," he said, "that will be worth something to us, if we do not have much in cash. If we lose the war, then it is not so important whether we have anything or not.

"We find to-day Government officials in high places coming to the steel men with the statement that they want our assistance; that they depend upon our loyalty and our ability to assist the Government in this time of great distress. It is to my mind a source of gratification that we may look forward to the future with hope and expectation that the Government of the United States is going to assist, to foster prosperity and business enterprises instead of attacking it."

Taking up the question of increased war taxation, Judge Gary said it did not matter how high taxes were provided they were distributed equitably."

"Taxes are liable to be much higher than they have been. There is talk of doubling the income tax and the excess profits tax and of taking many other lines of industry or activity. And we may expect very much greater hardships. We know that our property — for most of us have some property—and the large interests which we represent will be more and more heavily taxed. But in defense of the rights, the liberties of the men of this country, in defense of civilization itself, we do not care what the expense is or will be provided it is equitably distributed, and provided, to the best of the ability of honest and faithful men, the money is well expended."

At the afternoon session H. H. Wheaton representing Franklin K. Lane, Secretary of the Interior, addressed the members of the institute upon a plan which the Interior Department is anxious to have adopted by Congress for the Americanization of industry by teaching the English language to all laborers in the great centres of activity and enterprise in this country.

The following officers were re-elected: President, Elbert H. Gary; First Vice-President, Powell Stackhouse; Second Vice-President, Wills L. King; Third Vice-President, Charles M. Schwab; Treasurer, Edward Bailey, and Secretary, James T. McCleary.

# EDITORIAL

## DR. ALFRED STANSFIELD.

With the object of formulating some decisive opinion as to the potential value of the Iron Ore deposits of British Columbia Dr. Stansfield is visiting the west at the present time. It is his intention to thoroughly examine the ore deposits, (both magnetite and hematite) the fuel position, and the limestone deposits, besides looking into the questions of transportation, and probable markets.

The result of this inspection and enquiry will probably decide whether British Columbia has the necessary natural resources, whether sufficient demand for iron and steel products can be relied upon, and whether the smelting should be by blast furnace or electric furnace. We have several times referred to this question in previous issues and hope, after the Doctor's return, to be in a position to publish reliable data concerning the proposition.

## METALLOGRAPHY.

Microscopical and physical methods for the examination of metallic alloys have shown remarkable development in the last few years, and now can be looked upon as a distinct branch of physical chemistry. The methods employed in this branch of study, the conclusions generally accepted, and the directions in which further research and study are needed can all be gathered from standard works. Amongst these may be classed: Microscopic Analysis of Metals, by Osmond and Stead; Introduction to Metallography, by Goerens; Metallography, by Desch; and Metallography, by Savoia. Many practical men engaged in the manufacture and manipulation of metals, and metallic alloys appear to stand in awe of this comparatively new science, and to assume that continuous and close study is demanded before, beneficial results can be expected. To a certain extent this attitude is justified because many men after learning to polish a specimen and focus it under a miscroscope assume that they are competent to express a positive opinion as to the structure and physical characteristics of a specimen. Only intimate knowledge and prolonged experience can enable an observer to express an opinion with a reasonable amount of certainty. A little knowledge may be a dangerous possession, but properly used and controlled it can provide useful assistance in connection with metals and metallic alloys. The demands of practical metallurgy, especially in the iron and steel industries, have been the motive of the earliest, and of many of the most important metallographic investigations. The study of physical structure has proved itself an indispensable auxiliary to chemical analysis in the scientific control of the metallurgical industries, an auxiliary of which the applications become more extensive and more important every year. From the standpoint of pure science also, the identity of the relations in metallic and non-metallic systems must not be overlooked. Geologists and minerologists are now making use of the methods and results of metallography to study the formation and metamorphis of igneous rocks. From the same source light is also being thrown into the hitherto obscure region of the cements and slags, and the science is capable of still further extension. The word "metallography" was formerly used to signify the description of metals and their properties. In this sense it is obsolete, and its reintroduction to designate the microscopic structure of metals and alloys dates only from 1892, since when it has been generally accepted, gradually receiving an extension of meaning to include investigations by other than microscopical means. By grasping the elementary principles of the science it is possible for the practical man to derive important and useful information. The physical structure of a specimen may be examined and by means of different reagents its various constituents can be identified. Again the value of metallography will be appreciated when rational efforts are made to perfect thermic processes, such as annealing, tempering and the like. Acting under the assumption that elementary metallography would materially assist many of those actively employed in the manipulation of metals and metallic alloys, we propose to take the matter up at an early date. A series of common specimens will be chosen, and the operations of preparing for microscopical examination given in detail, a satisfactory examination demands the differentiation of the various components of the product dealt with: Advantage being taken of their several properties to develop the picture of the internal composition, as it were, on the polished surface. Different methods are used to aid in this result which include, mechanical action, mixed action (mechanical plus chemical) chemical action, and electro-

lytic action. Heat also is used as a means of tinting, or oxidizing, the surface of polished specimens. Partial and localized oxidations are produced on the sample, and often suffice to point out the composition of the metal. Samples of grey and white cast iron, the whole range of carbon steels, tool steels, high speed steels, and special alloy steels, will all be taken under review and it is hoped that the information so afforded may be of assistance in plants where a trained metallurgist is not available. Another service may be to in some cases create an interest in the science of metallography, and in others to foster an interest already existing.

## FROM SIR ROBERT HADFIELD.

The following favour from Sir Robert Hadfield is self explanatory, and we are glad of the opportunity to publish his remarks. As an indefatigable worker in the realm of metallurgical science, Sir Robert is known in every part of the world, as chairman of Hadfield's Limited, he controls one of the most important and progressive of steel producing plants, and his name must always be associated with the introduction and development of manganese steel. It would exceed the scope of this article were we to enumerate even a portion of his activities, but when the history of the war comes to be written, his services to the British Government and the allied cause will provide matter for a most important chapter.

"I am asked to contribute a few words to "The Book of British and American Friendship." This Book of the two countries ought never to have been closed. It was a colossal mistake on the part of certain of our Statesmen in the past which led to the severing of the interests of the two countries which, by the greatest of all bonds—"Nature"—were meant to be ONE. However, that is past, and a new book is opened, one full of promise for the World's future.

I should imagine that outside the Kaiser-Junker Classes, even the Hun himself would prefer to be under Anglo-Saxon laws and customs rather than his own. At any rate, judging from the number of Huns who have flocked to the United States and to the outlying Districts of the British Empire, they found some things in those parts of the World which do not exist in the Fatherland.

It is now some thirty years since I paid my first visit to the Wonderful Land over the Seas—the United States of America. It was to me a great surprise to find that there could be any one in either that Country or my own who imagined we were not meant to pull together in this World. Late events have shown this in a still more striking manner. If we do not work hand in hand, Justice and Liberty will, alas! have a sorry time in the near future should it ever be possible, which thank God it is not, for a "Pax Germanica" and not a "Pax Anglica" peace to be declared.

In my travels through the United States, from North to South, from East to West, I have always been struck with the breadth of opinion prevailing there, and the charity shown to individuals of all classes and nationalities. There is a little of Sectarianism in America, and religious differences hardly exist thanks to the broad mindedness shown by its citizens. Let us have a greater infusion of that spirit in our own Empire. It is almost impossible to conceive such a difficulty there as we have now to face in Erin's Isle. The great Federal principles adopted in America are of the utmost and most vital importance to the Anglo-Saxon race everywhere. Let us, who form such an important part of that race, not neglect but profit by the experience of our cousins across the seas. Each individual Anglo-Saxon, whether on this or that side of the Atlantic, should—and I am certain will—benefit by mutual experience.

Terrible as the war is, it is worth passing through its deep waters to weld together the two great English-speaking peoples in an indissoluble union which could have been brought about by no other means than the community of suffering and sacrifice the war involves. When America "came in," as I always felt sure she would, the future of the world was rendered safe, not by her power and strength alone, but by her wise example in the system of Democratic Government she has established.

As an instance, I am at the present time trying to rouse interest here in the excellent system of Patent Laws which America has founded, stimulating and encouraging invention as those laws do. We cannot do better than follow her example.

In another respect, too, we should follow the wise co-ordination America has introduced with regard to her Technical Societies. In the great building in West 39th Street, New York, known as the Engineering Societies Building, some 300 feet in height, are housed the five leading, and some two dozen smaller, Technical Societies, representing a membership of no less than 58,254. There is one common meeting-place and one large library, containing 160,000 volumes of Scientific and Technical books. We are greatly in need of something of the same kind here, many of our Technical Societies having literally no home of their own.

Finally, I should like to take this opportunity of expressing my own indebtedness to the United States, from whom I have received so much hospitality, courtesy, and help in my way through life.

Hail, Columbia! May no limit be set to the greatness of her Future. We know her citizens will ever support the cause of Justice and Freedom, not selfishly for their own benefit but for the benefit of the world at large. Within our Empire—the British Empire—there is and can be no jealousy of her success, and, if I may prophesy, I venture to say that future generations of the Great Republic and of the British Empire and the Dominions will count it gain, notwithstanding the immense loss and sacrifice, that the Great War forged bonds of union between the two countries, for the inestimable advantage of the world at large, which can never be broken."

## IRON AND STEEL PROTECTED BY PORE-FILLING OXIDE.

Iron and steel are said to be permanently protected against rust by a process of treatment that is now being used commercially. The material is placed in an oven and heated to a temperature of 1,050 deg. F., while subjected to the action of certain gases. Dry steam is introduced and an oxide formed that penetrates the pores and covers the outer surface of the metal. After an hour in the oven, the material is removed and permitted to cool gradually. It is then submerged in heated paraffin oil, which neutralizes the chemical deposit and produces a permanent black finish, after which it is dried in sawdust.

# Operating Characteristics of an Electric Reversing Blooming Mill

E. D. JEFFERIES, Electrical Engineer, Steel Co. of Canada.

It has only been within the last five years that American rolling mill engineers have given serious consideration to adapting electric drive to the two-high Blooming mill, although this system of driving a reversing mill has been in operation in Europe for over 15 years. It is the purpose of this paper to take up a few of the operating characteristics of a 34-inch reversing Blooming mill in the Steel Company of Canada's works at Hamilton, Ont.

The Ilgner system, which is used to drive this mill, employs a heavy fly-wheel in conjunction with a motor-generator set and a device that will enable the fly-wheel to give up some of its stored rotative energy when the demand for power is great, thus reducing the peaks, which would otherwise have to be furnished by the motor. During idle periods such as between ingots and passes, the motor speeds up the fly-wheel and thus replaces its rotative energy. It is necessary to interpose such a fly-wheel between the source of power supply and the mill motor in order that the mill may be started, stopped, reversed and controlled in speed with a minimum loss of time; to accommodate wide variations in power and to permit of a very simple means of control.

With the principal exception of auxiliary methods for operating an efficient adjustable speed control of large inductive motors, no application of power for rolling steel has received such impetus in recent years as has the reversing current mill drive. In the last three years there has only been one or two steam driven installations in comparison to about 25 electrically driven mills, this great increase in motor applications is undoubtedly due to operating figures covering first cost, maintenance, operating costs, and characteristics that the pioneer equipment to be described brought about.

### Description of the Ilgner System.

The Ilgner set consists of a fly-wheel motor-generator set, slip regulator, an exciter, a reversing motor, and control apparatus. The motor generator set consists of an 1800 h.p. 2200 volt, 3 phase wound rotor induction motor; a 50-ton fly-wheel and two 1200 kw. 600 volt d.c. generators, all mounted on a common shaft. The slip regulator or water rheostat, is operated by a torque motor, the current for which is delivered from a current transformer located in the main leads to the motor. The exciter is of 175-kw., 250 volt capacity and supplies all current for the motor and generator fields. The mill motor is a shunt-wound interpole motor, two units on one shaft, rated at 3000 h.p. (continuous) and capable of delivering momentary peaks of 9000 h.p. The control consists of a vertically operated drum-type controller about the size of a street car controller, which operates shunt-contractors. These shunt contractors control the direction and speed of the mill motor by changing the polarity and varying the resistance of the field circuit of the variable voltage generators. In order to prevent the motor from being over-loaded, a current relay placed in the main leads of the mill motor operates an overload and introduces resistance in the field circuit, thereby decreasing the field strength

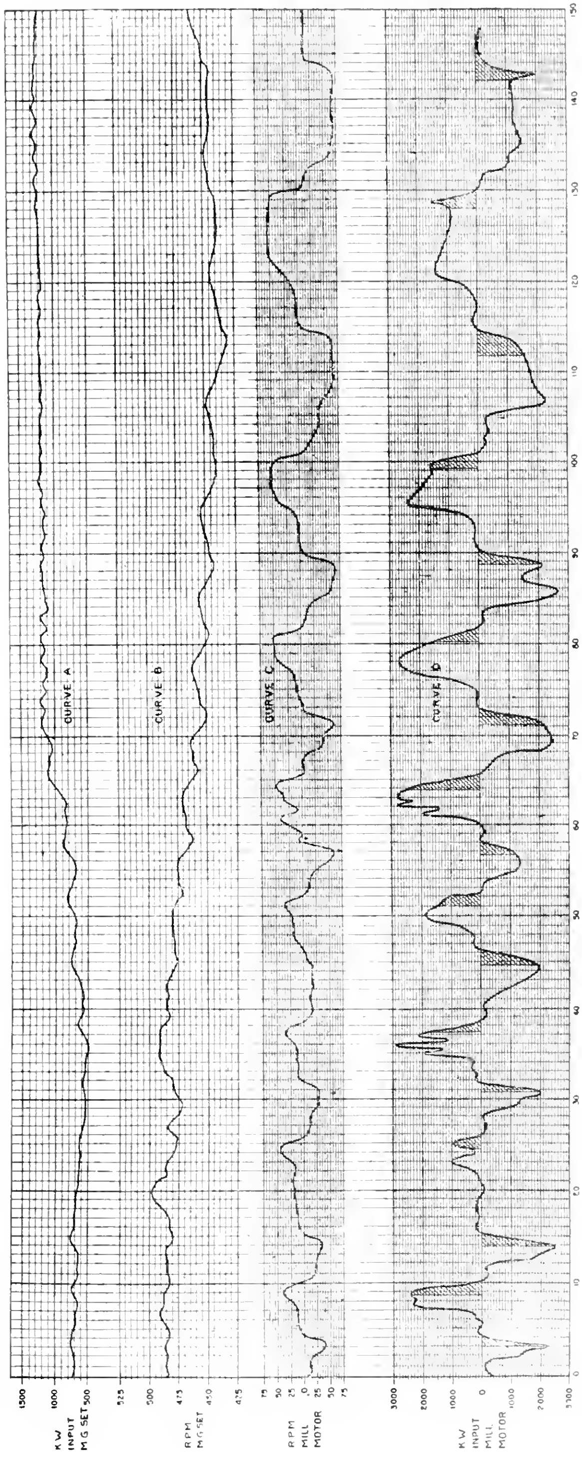
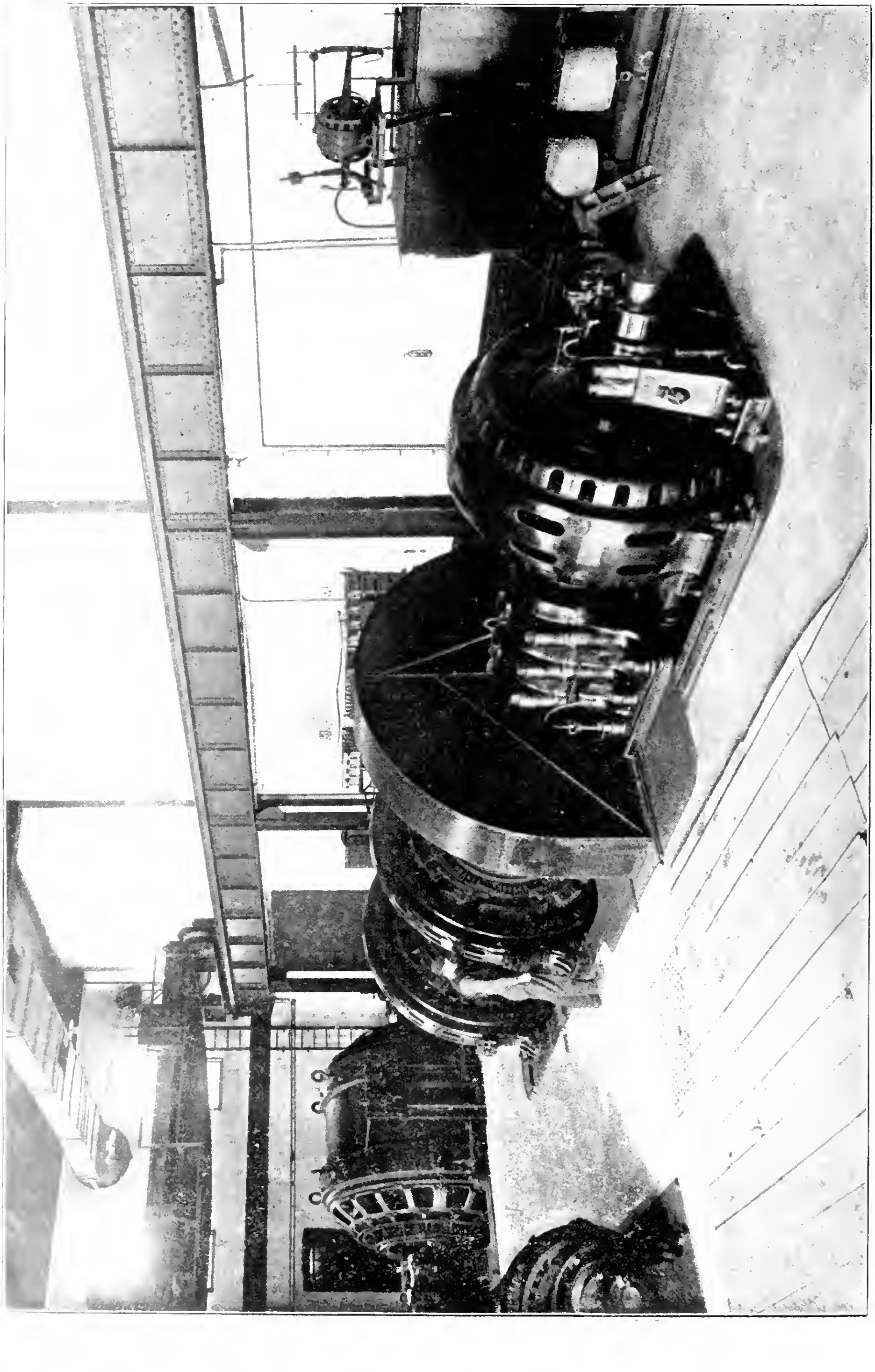
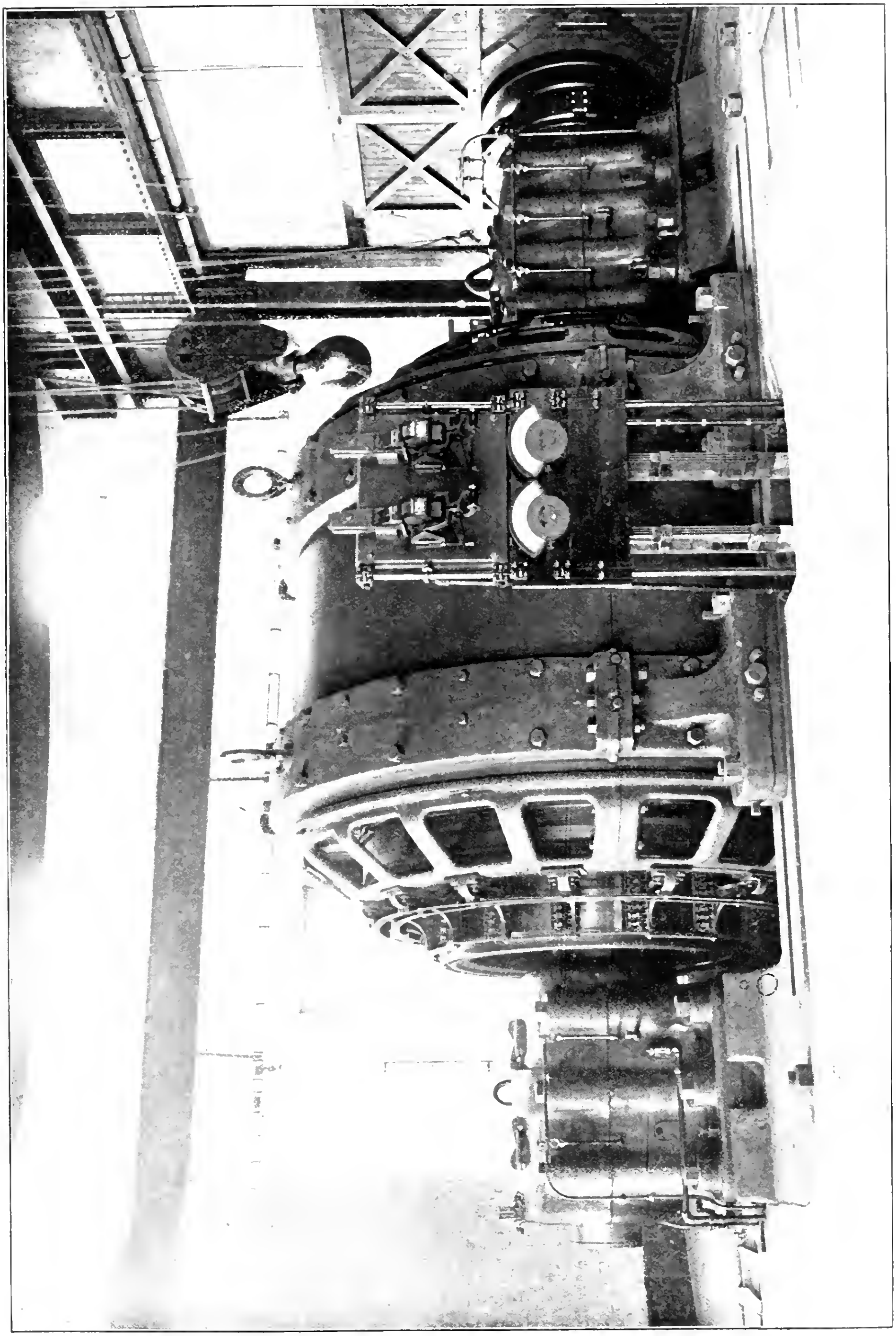


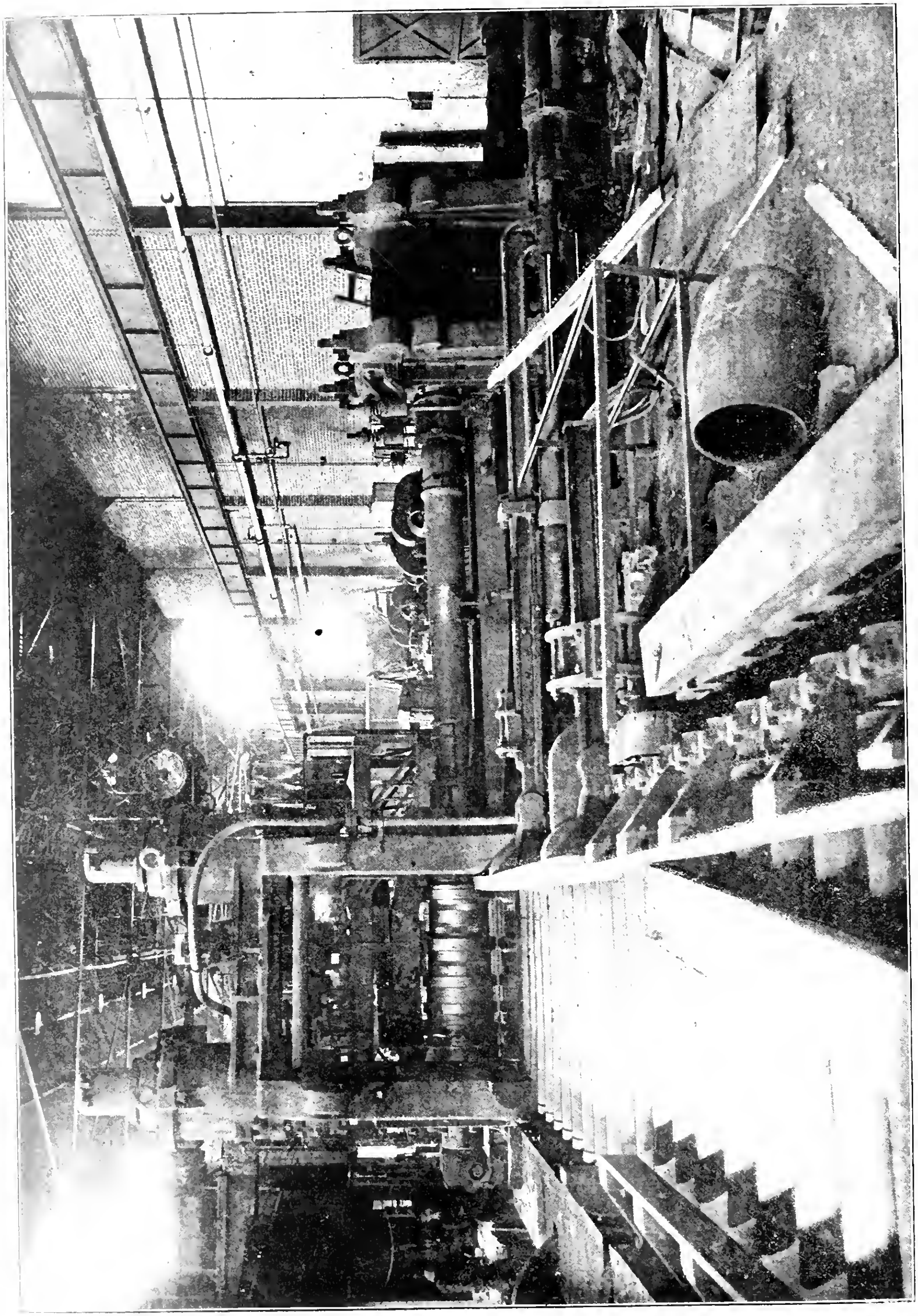

Fig. 1



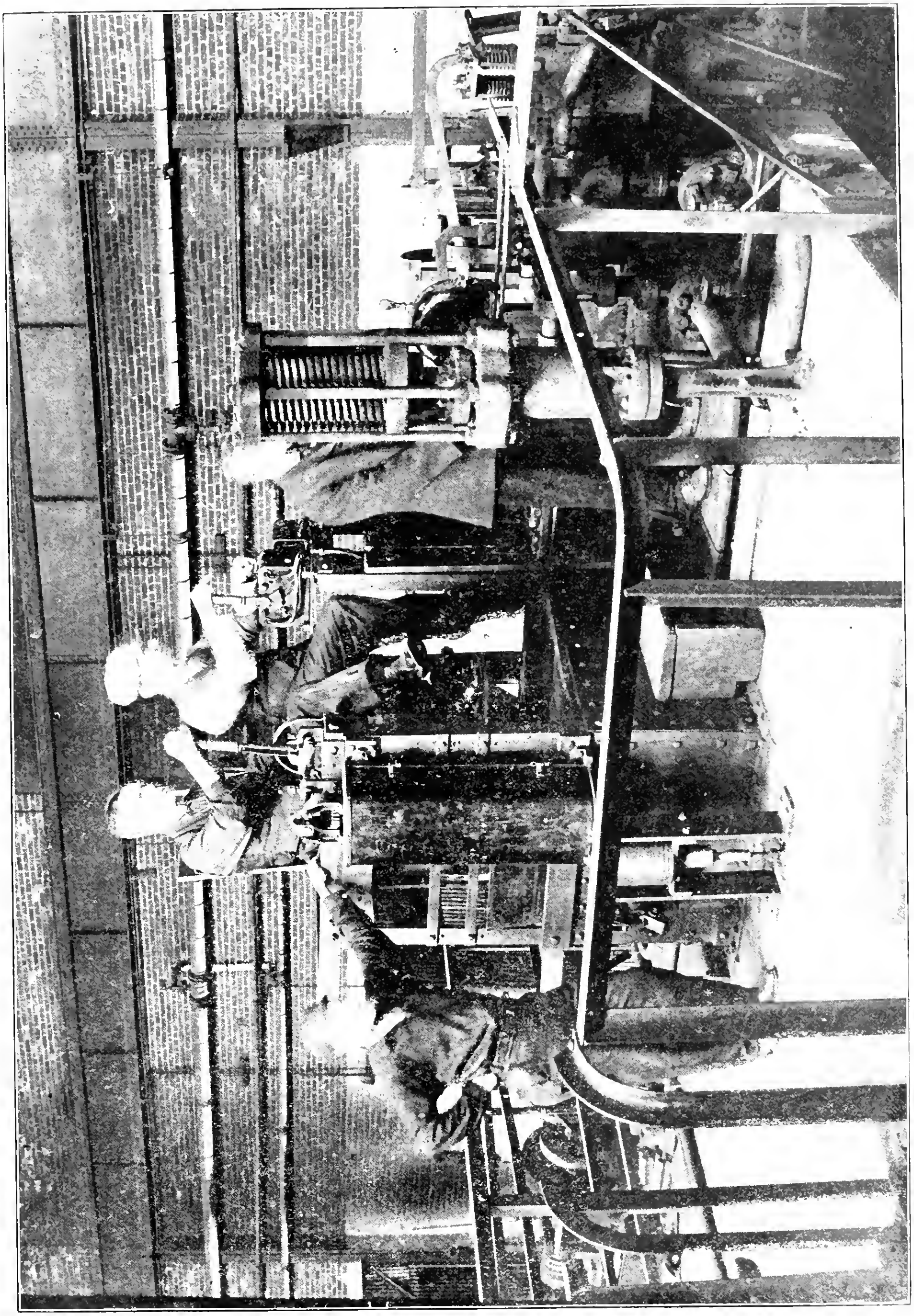
GENERAL VIEW OF ILGNER SET ELECTRIC ROLLING MILL.



MAIN ROLL MOTOR ELECTRIC ROLLING MILL.



GENERAL VIEW OF 34-INCH MILL, ELECTRIC ROLLING MILL



OPERATORS' PULPIT, ELECTRIC ROLLING MILL.

and generator voltage, which in turn limits the torque. The motor fields are excited constantly in one direction, but for speeding the motor for long passes, series resistance is introduced.

The characteristics of this system are clearly shown in Fig. 1, which represents graphically the kilowatt input to motor generator set (Curve A) the variations in speed of the motor generator set (Curve B), the speed and direction of the mill motor (Curve C) the input to the mill motor (Curve D). These curves, while not an average of observations, are typical curves taken simultaneously, and illustrate the action of the slip regulator and fly-wheel in minimizing the fluctuations in power demand. In this case the maximum input is about 1200 kw., the speed of the fly-wheel varying between 490 maximum and 435 minimum, whereas the load on the mill ran as high as 3000 kw. As the rotative energy of the fly-wheel is proportional to the square of the speed at which it is turning, a reduction of 15 per cent in speed means that $27\frac{3}{4}$ per cent of the whole rotative energy of the fly-wheel is absorbed during the short period of speed change. Normally between 15 and 20 per cent reduction of speed is allowed. The shaded areas of Curve "C", 27 per cent of input, are periods during which the rotative energy of the mill motor in reversing is returned to the fly-wheel set, i.e., over 60% of the rotative energy of the mill motor, rolls, and which is lost in steam driven mills, is saved in an electric driven mill in this manner. The time of acceleration of the mill motor from practically zero to full speed, is only one and one-half seconds during some of the short passes, and of course lengthens out for the long passes.

Fig. 2 shows the efficiency of the Ilgner set taken as a unit, based on approximately 200 tons of finished $3\frac{1}{2}$ x 4 inch billets, all data being taken from Curves "A" and "D." In Fig 1 the input, as shown by Curve "A," being 139,043 kilowatt seconds, which gives 19.81 kw.-hrs. per ton of steel and an average input of 959 kw. One hundred per cent load of the efficiency curve is based on rolling at this rate; the output was obtained by plotting a curve parallel to Curve "D," which allows for the inefficiency of the motor. It is interesting to note how close the above 19.81 kw. hours per ton agrees with Curve in Fig. 3 taken from actual operating conditions. This indicates that the efficiency curve is fairly reliable under the conditions assumed, which conditions are maximum tonnage and minimum size that is possible to be rolled on this mill and fly-wheel set not disconnected from line.

### Costs.—(Power Cost 2 3c K.W.H.)

TABLE NO. 1 (Operating Cost Per Ton).

| Year | 1913 | 1914 | 1915 | Average or total | P.c. |
|---|---|---|---|---|---|
| Operating | 9 Mo | 8 Mo. | 12 Mo. | | |
| Tonnage | 119,230 | 92,622 | 174,460 | 386,312 | |
| Kw. Ton | 23.9 | 22.8 | 21.5 | 23.4 | |
| Power Cost | .160 | .153 | .144 | .157 | 86.8 |
| Repairs & Maintenance | .0069 | .0092 | .0045 | .0064 | 3.5 |
| Miscellaneous Supplies | .0045 | .0049 | .0025 | .0036 | 2.0 |
| Labor in Operation | .0141 | .0161 | .0128 | .0140 | 7.7 |
| Total Cost | .1855 | .1832 | .1638 | .1810 | 100.0 |

TABLE NO. 2 (Total Cost of Steel Rolled Per Ton).

| Year. | 1913. | 1914. | 1915. | Ave. |
|---|---|---|---|---|
| Total operating Costs (No Overhead) | .185 | .183 | .164 | .181 |
| Interest on Investment ($156,000.00) | .078 | .101 | .054 | .073 |
| *Depreciation (20 years) | .065 | .084 | .045 | .060 |
| | .328 | .368 | .263 | .314 |
| *Miscellaneous | .126 | .133 | .115 | .117 |
| Total | .454 | .501 | .378 | .431 |

In table 1 herewith, a comparison is given of three operating years and an average covering the same period. In 1913 the mill operated nine months, and the rate per ton is high, as would be expected for the first period of operation. The 1915 figures show a very fair year considering the tonnage rolled. The individual items will represent very closely actual continuous running figures for any comparison, allowance being made for variations in tonnage. The operating expenses, without any fixed charges, are shown here under the headings of labor, repairs, maintenance, and miscellaneous supplies, which total for the year 1915 only $.0198.

The figures in Table 2 show the total cost of steel rolled per ton in our mill The depreciation as shown herewith does not cover any question of obsoleteness, but considers the equipment valueless at the end of a twenty-year period. The last item, miscellaneous, is a charge covering all electric light, power used for cranes, pumps, tables, conveyors, etc., in the blooming mill, and the plant over-head charge.

The figures given under a heading of "Average" seem to be very fair figures to cover any emergency, and careful analysis by the author seems to indicate that the total figures would cover any unforeseen condition that might arise. The largest item, power cost, is exact as it is metered, and the other items are charges made direct with no estimating, the result being that the total is an exact cost without any estimation whatever in arriving at the results. These are the actual book figures.

Coming to the question of the advantages of the Ilgner System, the writer sees them as follows:

Low Cost of Power:

Low cost for repairs and maintenance;

Stand-by losses nil;

Small time to get under way from complete shut-down to rolling conditions;

Few delays necessary;

Part of rotative energy of mill parts recoverable for useful work.

Speed proportional to displacement of controller lever from off-position;

Simplicity of control;

Motor does not race when steel leaves rolls;

Constant turning moment;

Mill breakage less;

Simplifies mill layout;

Small area or ground space needed;

Lends itself to centralization of power;

Ideal load to add to any generating station;

The floor space necessary for the equipment described was 40 ft. x 125 ft., which allows ample room

*See Text.

between machines and wall and switchboard, no apparatus being cramped in any way. A 40-inch mill could easily be installed in this same area. In case of necessity the fly-wheel set need not be located in close proximity to the mill motor so that in adapting a mill under extreme conditions where very little floor space was available, the fly-wheel set could easily be located some distance away where floor area could be obtained. The real estate charges on some mills located in thickly settled communities must be considered, and in comparing this area with the area necessary for boilers, coal handling machinery, steam engine, pumps, etc., the comparison is very good.

After the mill has been down for Sunday, the time necessary for the attendants to have the entire equipment ready for maximum rolling conditions is less than 10 minutes. It is doubtful whether a steam boiler equipment could be gotten under way from absolute standstill to running conditions in less than four hours. The simplicity of the control as compared to the levers, links and auxiliary cylinders necessary for

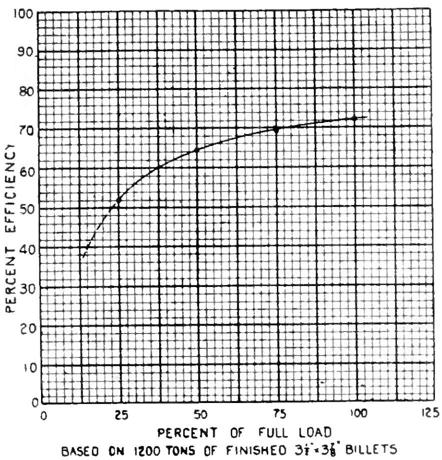



**Fig. 2**

the steam engine is noticeable in the photographs showing the pulpit of this particular mill. The entire control wiring between pulpit and power-house is contained in a 1-inch conduit pipe. All parts of the control are entirely accessible and any part needing repairs can be changed in a very few minutes. Not considering the period of development immediately after installation, our repairs have been exceptionally low, probably the largest item being the brush renewal, but this item is very small indeed. Delays in the last three years due to this equipment exclusive of development period, have not amounted to twenty-four hours, and this period was taken up at various times more to be doubly sure that the equipment was in good order rather than take any chance. This time was taken by such things as part of a band breaking off, loose connections, ground on the field circuit, etc.

When the mill is idle there are no losses, as the fly-wheel set can be disconnected from the line and allowed to rotate, which means that there is absolutely no losses when the mill is idle, as compared to steam equipment having to keep the boilers under steam, the steam-line condensation, small leaks, etc. When the steel leaves the rolls there is no racing as would be the case in the steam engine run by an inexperienced operator, the motor maintaining uniform speed corresponding to the displacement of the control lever from off-position. Such complete control of the speed of the mill lends itself ideally when steel is entering and leaving the rolls, as there is no change of speed unless the operator so wishes. The motor exerts a constant turning movement in all positions, whereas the double crank engine has two weak places in each revolution, and one place in particular where the turning moment is very low. The saving due to the return of the rotative energy of the mill parts to the fly-wheel gives a means of saving power which is normally lost in steam driven mills. If 60 per cent of the rotative energy of the mill motor is returned to the fly-wheel, 60 per cent of this, namely, 36 per cent of the whole is available again on the mill shaft for active work.

To any plant, whether purchasing power from central station or receiving power from its own power-house, the Ilgner system adds an ideal load, due to the fact that it is a fairly constant load. If the mill is run to capacity the power variations will be very slight. A central station load applies in the same way and lends itself, where power is being purchased on a peak basis, to a very low rate. For a large power plant, the increased load does not amount to very much; taking as an instance of this the Hamilton mill: a 1200 kw. generator capacity would easily take care of the load. Where mills are located at various

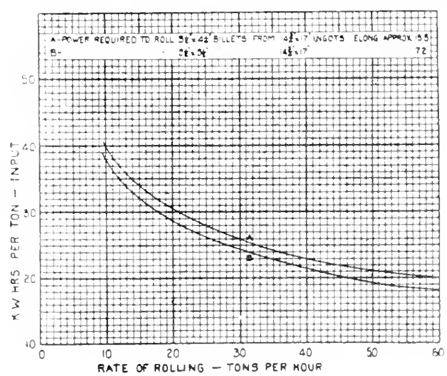



Fig. 3

points in the plant, which from a steam power point of view is inefficient, the Ilgner system eliminates such inefficiency by centralization.

The exceptionally low cost of power is probably the most striking feature of this system, the figures shown being actual figures in no way having been adjusted for cost-keeping purposes. The simplicity of the mill lay-out is another feature which must be considered. The figures herewith show this advantage very clearly in regard to mill breakage. In the four years this mill has been operating, the only parts broken were the coupling boxes on the motor coupling, due each time to the metal slipping between the rolls. During the

first few months four coils were burnt out in the motor, but after this trouble was cleared up there have been no breakages in the entire mill with the exception of the coupling boxes.

There is a very interesting point in operating this system of drive to any reversing mill, in that it is possible where one or more reversing mills are located near each other and their products being associated and dependant on each other, that it is possible to drive more than one reversing mill from a common motor generator-set, there simply being a corresponding number of generating units, either 1 or 2, as the case may be for each mill. The saving in first cost of one motor generator-set equipment, and the saving peak loads on the power station and cutting down the weight of the fly-wheel undoubtedly amounts to a considerable item.

---

# Man Power

By J. PARKE CHANNING, New York, N.Y.

(Colorado Meeting, American Society of Mining Engineers, September, 1918.)

We are accustomed to think that we are efficient in the United States, particularly with respect to such things as mining and manufacturing. The conduct of the war has demanded in England and in France a complete readjustment of manufacturing methods and plans, and today England is probably as efficient a country as there is in the world, not even excepting Germany. This is all the more remarkable because it has been notorious for years that England has been inefficient in her manufacturing and the country has been flooded with things "Made in Germany." Today England is almost a socialistic community and the State is doing almost everything. England is now in such a position that practically everyone in the country is engaged in industry necessary for the conduct of the war, and this has been accomplished by increasing the efficiency both of her tools and of her man power.

In the United States we certainly have been efficient so far as machines and perhaps so far as methods have been concerned, but we have not been efficient in the utilization of our man power. Before the war, our labor was undoubtedly far more efficient than that of England, but it certainly was not so highly efficient as it should have been, and the problem that confronts us today, and will all the more confront us after the war, is to make our man power efficient. England has had a taste of what you may call state socialism, and her laboring men are not going to be content to return to the old order of things. There is one feature of the labor problem in England which has permitted her to reach this condition of state socialism with comparative rapidity; this is that practically all of her laborers are English; she has little or no foreign population. While an Englishman may be a strong union man and ready to fight his employer tooth and nail, at heart he is still a British subject, and when his country was in danger he rose to the occasion.

In the United States we have such an admixture of unassimilated foreigners that the problem is more difficult, and as yet we have not been brought to that point of stress which has arrived in England. But if we are to carry the war to a successful conclusion, and if we are to increase our efficiency after the war, we must introduce methods which will Americanize these foreigners and give them our own point of view. We have been called the melting pot, but it is a question whether even our melting is efficient, and whether at the top of the crucible there does not accumulate too much dross and at the bottom not enough clear alloy.

I wonder if any large number in this country have read the so-called reconstruction programme of the British labor party. It will, of course, be subject to a great many modifications before it is adopted by the party, and no doubt still further and greater modifications will be made before any or all of it is accomplished. It is very largely socialistic and has for its basis four principles or pillars, as they choose to call them, of the house which they hope to erect. These four pillars are:

1. The universal enforcement of the national minimum.
2. The democratic control of industry.
3. The revolution in national finance.
4. Use of surplus wealth for the common good.

If these four demands are carried out, then surely England will be a socialistic state.

I am not prepared to say how much of this programme can, or will, be carried out, but it shows the trend of thought of the laboring man in England. He has seen his wages increased so as to keep pace with the growing cost of living, he has seen the profiteer discouraged, and he is more than ever convinced that in the past he has not been getting his fair share of the product of his toil; and, I believe, at the same time he is realizing that undoubtedly in the past he has not done his proper share in increasing the wealth of the country. Nor can he be blamed for this, because, seeing large fortunes grow up before his eyes, while he gets but a small proportion of it, the incentive to increased efficiency has not been great. He realizes that when the war is over, unless the greatest care is used in the reorganization of the regular industries, there will be an immense amount of unemployment; that this, if unchecked or uncared for, will result in an over supply of labor, and, if the old standard is maintained, a corresponding diminution in wages. This he feels should not be; hence his insistence of the first principle of a minimum wage. And the minimum wage that he asks for is certainly not a high one, being 30s or, we will say, $7.50 a week.

In demanding democratic control of industry he has observed such good results attained in war work that he sees no reason why this control of industry should not be just as efficient under after-war conditions.

In the third pillar, the revolution in national finance, he demands that taxation shall be so adjusted that it will yield the necessary revenue to the Government without encroaching upon the prescribed national minimum standard of life of any family whatsoever; without hampering production or discouraging any useful personal effort, and with the nearest approximation to equality of sacrifice. Apparently he is

not a protectionist and repudiates all proposals for a protective tariff; however, this may be disguised. In this point they agree with Mr. Courtenay de Kalb, a prominent mining engineer, who, in the December, 1917, number of the Atlantic Monthly, has a most excellent article on the Formula for Peace, in which he states, that, if after the war we can have an industrial world in which there are no protective tariffs and no subsidies, in which every nation is engaged in producing those articles for which it is best adapted, that then there will be less incentive for war.

The fourth pillar of the English laborite is that the surplus wealth shall be used for the common good. They say that we have allowed the riches of our mines, the rental value of the land superior to the margin of cultivation, the extra profits of the fortunate capitalists, and even the material outcome of scientific discoveries, to be absorbed by individual profiteers, and he demands that in the future a large proportion of this surplus shall be applied to the common good.

You must realize that the English labor party is not like the Bolsheviki of Russia. It is not carried away with the beliefs of Lenine and Trotsky, that the proletariat are the men to manage the country. The English laborer frankly realizes the importance of brains and education, and admits that the highest success of the country cannot be obtained without the aid of those who plan, and manage, and invent, nor would he object to allowing these men to get their fair share of the profits. Evidently the class against which his programme is aimed is comprised of those more or less sharp and shrewd men who, without anything more than commercial ability, of themselves reap the advantages of the brains and muscles of others.

It is not for me, nor am I a sufficient student of economics, to pass upon this programme. It has certain merits, and I am calling it to your attention only that you may see that just this same thing is liable to come up in the United States. And the trouble will be that the pendulum will very likely swing too far if the employer class in the United States does not give more attention to the laborer and see that his condition is improved. You, as engineers, are in the position to act as the instruments for carrying out this necessary work. Whether it be in a mine or a manufacturing plant, I believe I can say that today a large proportion of the managers and executives are engineers, and the proportion is constantly increasing.

The question to be clearly faced is, are we properly trained to bring about this improvement in our social condition, to improve the living conditions of our laborers and at the same time to improve their efficiency. I fear that a great many of us are not. We may be good technical men, but we are not sociologists nor psychologists. We understand production of kilowatt-hours from coal or from water power, we understand the machine by which it is utilized, but we do not understand the machine which produces our man power.

I recently attended a conference at Columbia University, at which the question of giving the engineering students a course in human engineering was discussed, and I came away with the idea that the authorities were beginning to realize that this was of paramount importance and that this training must be given the engineering student before he can be turned out as a man capable of eventually holding a high executive position. Many of the students have the ambition to hold high positions, but at the same time, in the most naive manner, announce that they have no desire to have anything to do with the working men themselves. In my opinion, there never was a time when it was so necessary to impress upon engineers and engineering students the importance of this human side of engineering.

I wonder how many of you can tell me what trade unionism is — you who have had to deal with unions and have had strikes? The fact is that none of you can tell what trade unionism is because trade unionism is not an entity but a term of broad generalization covering a great many distinct aspects of the labor problem. Some of you who, perhaps, are railroad superintendents, whose knowledge of trade unionism is based upon your contact with the Brotherhood of Locomotive Engineers, would give one definition; others, who have been managing a mine in the Rocky Mountains, whose contact has been with the Western Federation of Miners, would give another definition. Specifically each of you would be right from his own point of view, but neither of the definitions would cover trade unionism as a whole. A few weeks ago I might have been rash enough to attempt a definition, but in the meantime I have read Professor Hoxie's work on "Trade Unionism in the United States," and my ideas on the subject have been much clarified. I would advise every one who has anything to do with trade unionism to get this work and not merely read it but study it as you would study a book on electric motors to find the difference between an induction motor and a synchronous motor, between one that was simply wound and one that was compound wound.

You will find that trade unionism can be classified under two broad general heads, one based on structural varieties, and one on functional varietes. As Professor Hoxie points out, there are four divisions under each head and anyone of the structural varieties may function in any one of four different ways. You will learn that while, to you, decreased output on the part of the laborer seems inexcusable, yet, for him, it has an intense and immediate value. You will find the reason why he insists that the good and the poor workman shall each turn out the same amount every day, and you will find that he has most excellent reasons for this, reasons that probably never entered your head. You will learn why the locomotive engineers of the United States can have one strong central national union, and why this is impossible with the men who dig ditches. You will discover why the Knights of Labor movement failed and why the American Federation of Labor has succeeded. There is one basic and most important factor which you must realize, namely, that, talk as you may, the interest of the laborer and the interest of the employer are diametrically opposed, just as the interest of the buyer and the interest of the seller are opposed, that from the very nature of things they can never be identical, and that the best that can ever be reached is a compromise. And who is better qualified to bring about this compromise than the well trained engineering manager who, with his broad knowledge and experience with both capitalist and laborer, is enabled to act as an arbiter or a judge and arrive at a decision at least fairly equitable.

It is the engineers of this country who are in a position to solve the labor problem, or at least to produce a solution as nearly ideal as possible. It is you who are to convince the employer that, in the long run, he is going to be better off by increasing the wages of his men, reducing their hours of work, and improv-

ing their living conditions. It is you who must convince the laborer that it is to his interest to work as efficiently as he can and to produce as large an output as is possible. You will have to do this by education. It is difficult to convince a laborer that by increasing his efficiency and his output he helps himself, because he only looks to immediate results. But do not be carried away with the idea that because the laboring man upholds an economic fallacy that you cannot convince him of his error.

About 10 years ago I started to develop a low-grade copper mine in Arizona. As mine superintendent I had Mr. N. Oliver Lawton, a member of this Institute, whose experience at Lake Superior has made him familiar with what is known as the one-man air drill. This is a light machine weighing about 125 lb., which can be readily set up and operated by one man. We started to use these in Arizona where, before, nothing but the larger and heavier machine, requiring two men, was in use. There was an immediate opposition from the men and we were accused of trying to throw half the normal number of miners out of work. Whenever I went through the mine I took the opportunity to tell the men that this orebody, up to that time, had not been considered ore, that it was rock, and that nobody thought it was worth exploiting; that, far from throwing one man out of work, we were giving two men jobs, that if two men had to work on a drill the cost of mining would be so high that the material would not be ore, but that if we gave each man a drill and put him to work in a separate drift, then the rock would become ore, that these men would have employment and that a new industry would be started. About 3 months of this propaganda convinced the men of the truth of our claim, and in a short time it would have been impossible to get the men to go back to the old two-man drill because each man now felt that he stood on his own feet and got credit for the whole distance he drifted. This is only one example, but it indicates what can be done by education. The old-time manager or old-time superintendent would simply have said, take the job or leave it; but this is not the attitude for the modern engineer.

The assertion is made in Washington that it is difficult to get executives for war work, particularly executives who understand the handling of man power. I am told that some of the new plants for war industries have been most carefully laid out, taking into consideration the routes by which material is to arrive at the plant, its progress through the works, and its method of removal, the supply of water, coal, and other material, but in a great many cases no thought has been given to the handling of the men, to their housing, or, if they are to be brought from an adjacent town, of the method of transporting them to and from the plant. These have been left to a hit or miss adjustment after the plant was up.

For several years the industrial department of the Y.M.C.A. has had a secretary who has devoted himself almost entirely to impressing upon the engineering schools the necessity for having a course in human engineering, and in 1916, under their auspices, the first convention to discuss the human side of engineering was held in Ohio. They lay great stress upon the advantages which would accrue to engineering students if they had an insight into the mental operations of the laboring man, and this has been fostered by getting the engineering students to volunteer one or more hours of the week for instruction to laborers employed in adjacent plants. This instruction is either in the English language, in citizenship, or in athletics. A man who has volunteered for this work for a year or more, on going out into active life is a much more capable foreman than one who graduates from an engineering school and meets his first laborer somewhere on his new job.

Lately the National Americanization Committee of New York, of which Mr. Frank Trumbull, of the Chesapeake & Ohio Railroad, is Chairman, has been conducting similar propaganda, sending to the various educational institutions of the country a proposed basis of a course on industrial engineering. The Committee realized the importance of this in preparing engineering graduates for the problem of properly utilizing the man power of the country. This proposed course goes into the scope of industrial engineering, describes the problem and the field; it takes up the question of the engineering insight of the work in reference to plant building, its location, and the fundamental considerations in its construction; it takes up the management and division of the work, the analysis of the costs, and the machinery, and the materials, and the efficiency methods. It goes into the question of employment, management, and the methods for hiring, promoting, and transferring men. It also takes up industrial welfare with the various incentives to the workman and the provisions for his health and recreation, and for the vocational training of either himself or his children. It also gives instruction in that branch which is so often neglected, and that is conditions outside of the plant, the housing of the men, the planning of the town, and the health and recreation and education of their families. It takes up the problem of Americanization and what shall be done to make our melting pot efficient, without dross, and finally it gives him instruction as to what has been done and what should be done in legislation.

You engineers who are college graduates should use your influence to see that courses in human engineering are introduced in your Alma Maters, if they are not already there.

Do you mining engineers realize that your training and your experience, touching as it does on all branches of engineering, fits you better for broad and important work than those in almost any other profession? How many of you have been under the necessity of developing a large mining property in some out of the way place, when everything came before you and nothing could be left to chance, where you had to see that your own town was built and provided with water works and sewers, lighting plant, and schools? You had to develop a property in a place where nothing existed and you did not have a well-organized community to fall back upon with all these adjuncts provided. Only recently one of my former superintendents came into the office to tell me that he had given up a $12,000 a year position to take one with the Government for $3,600. He did not hunt this Government job, it came after him. They asked him to go on to Washington and take a job in the Ordnance Department. They said that they had found that a mining engineer has had such varied experience, and has driven so little in ruts, that at a minute's notice he can jump from 6-in. projectives to baled hay.

NOTE.—This paper was presented at the meeting of the Boston Section of the American Institute of Mining Engineers, March 15th, 1918.—Ed.

## F. H. CROCKARD,

### President Nova Scotia Steel & Coal Co.

A famous poet once said "there is a tide in the affairs of man which taken at the flood leads on to fortune." We presume the same might be said of a corporation. In the ordinary course of events a man or a company may get to the end of their tether and it requires some outside stimulant to bring about a further expansion.

In a previous character sketch in this magazine the story was told of how Col. Thomas Cantley beginning his business life as a telegraph operator with the Nova Scotia Coal & Steel Co., saw it grow, and grew with it, to its present huge dimensions. A short time ago he realized that the burden of further extending and expanding the company's manifold activities must rest on younger shoulders. For this purpose he brought Frank H. Crockard from the Tennessee Coal, Iron and Railroad Co., and shifted the burden of responsibility to his broad back.

Frank H. Crockard was born in the business, his father being a furnace superintendent at the Riverside Iron Works and the boy grew up with the fumes of ore in his nostrils and the glare of the furnace fires in his eyes as a beacon to beckon him onward. Like the Israelites of old the forge fires of his father's foundries acted as "a cloud by day and a piller of fire by night," and were destined to lead him out into the world of affairs where he was to do a man's work. Later he was sent to college and graduated from Lehigh University, then came a course at the Michigan School of Mines. Crockard came out of college to put his theories into practice by becoming foreman in the Riverside Iron Works. The young man, however, was becoming more than a mill foreman, the dull routine of mill management was to give place to the creation of bigger ideas. Crockard's forte in life was to organize and revitalise industries. His first effort in this line was to rehabilitate the Jefferson Iron Works at Steubenville, Ohio. Having put this concern on its feet he returned to Riverside as blast furnace superintendent, later being promoted to assistant manager. As the concern was the second largest steel pipe mill in the United States his new position was one of great responsibility.

About this time the Gates interests secured control of the Tennessee Coal, Iron and Railroad Company and decided that they needed a strong man to rehabilitate the property. Having been directed to Crockard's good work at Riverside they induced him in 1906 to take over the management of their interests. He continued with that company even after it was taken over by the U. S. Steel Corporation, and until the Nova Scotia Directors grabbed him up and put him in charge of their big interests in the Maritime Provinces.

The Nova Scotia Steel & Coal Co., had its inception in a little blacksmith shop at New Glasgow, from that company grew and expanded, taking in new departments one by one, acquiring coal and iron ore properties until at the present time it is one of the most important industries in the Dominion. In addition to manufacturing all kinds of steel commodities they have gone in for shell making on a very large scale, for steamship building, for car building and many other subsidiary undertakings. As a matter of fact the concern has grown to such large dimensions that it will require the best efforts of the ablest organizers procurable to maintain the momentum acquired during the past quarter of a century. In an effort to enlarge its business the company recently doubled its common stock, which will provide the necessary capital for whatever extensions and improvements may be decided upon from time to time by the directors. That Mr. Crockard is eminently qualified for the carrying out of these schemes is shown by his past history. When he left the Tennessee Company, President Gordon Crawford issued the following statement:

> "Mr. Crockard has rendered loyal and efficient service and his departure is regretted. In leaving, he takes with him the respect and esteem of his friends in the Tennessee Company and their best wishes for success in his new field of work."

The task confronting Crockard to-day while tremendous and calling for the best in him is entirely different in character to the problem which faced the organizers of Scotia a generation ago. To-day the company's credit is assured among bankers, brokers and investors. A generation ago it was non-existent. To-day a trained staff of workers, great ore bodies, huge buildings and the best in the way of equipment aid in further development and expansion.

When the company was first emerging from the blacksmith shop stage the whole project was in a formative state. The little town in which their plant was located was far from the beaten track of the world's highways. Manufacturing was an untried experiment in the Maritime Provinces. Many wise people doubted the possibility of success, arguing that if it had been a profitable enterprise others would have taken it up long ago. However, the men back of the Scotia Company were determined to develop the latent resources of that district. The great iron ore reserves and the coal areas which had been almost untouahed appealed to their imagination. In vision they saw the little blacksmith shop with its one forge replaced by huge buildings with smoke stacks towering against the sky line, with open hearth furnaces and electric smelters replacing the hand forge, with shipbuilidng plants, car shops, and various other subsidiary concerns employing thousands of men. They were handicapped through the lack of shipping facilities, by shortage of labor, through the want of technically trained workmen and by being located in an unknown and out of the way place, but looked upon all these difficulties as an additional incentive to hard work. To-day that is all past but new and larger problems are being faced and solved. In the hands of the president of the company no person doubts their ultimate solution.

That Crockard has many years of activity ahead of him almost goes githout saying, as he is in the prime of life, having been born 43 years ago at Wheeling, West Virginia. Canada welcomes Crockard to her industrial life.

---

We herewith acknowledge the courtesy of the International Press Association in lending the photographic blocks of Messrs Franz and McDougall, which appeared in our last issue.

## W. M. CURRIE.

### Vice-President and Managing Director, Burlington Steel Company.

One is apt to think of steel men being stern and unbending, something like the steel girders or iron rails they produce in their mills. In fact one can hardly imagine these captains of industry being the genial soul that we would know Andrew Carnegie to be, or to possess the sunny smile of Charlie Schwab, now engaged in speeding up ship production in the United States. Strange as it may seem—steel men are nearly human—and after one gets through the filings or whatever the outer crustings may be called, the man inside is found to be a real decent chap, keeping as many of the commandments in the Decalogue as journalists or other respectable citizens.

W. M. Currie—Vice-President and General Manager of the Burlington Steel Company, Hamilton, Ont., is a case in point. By this we do not mean to infer that "Bill" Currie looks as if he were a magnet encased in filings or that he possesses a crude and uncouth exterior. Anyone casting a casual glance at the outlines of the cut accompanying this sketch will at once recognize the fact that William Mark Currie is as handsome a chap as is found in a day's journey. Those of us who know him well realize that there is no alloy in his make up, but that he is as true as steel all the way through. In the old 'Varsity days, Bill Currie had more than his share of friends—of both sexes. As a matter of fact, those who knew him best predicted that in the days to come he would occupy a very prominent place in the particular field for which he had fitted himself. Currie was a good student, a good chum and a good all-round fellow, and it is with no small degree of satisfaction that his friends find their early predictions coming true. Currie was never afraid of hard work—time-clocks and union hours never bothered him, when he had a job to complete. After a distinguished career at the School of Practical Science in the University of Toronto, he became assistant engineer of the Westinghouse Electric Co. of Pittsburgh, a training ground for thousands of electrical and mechanical engineers. After a short time with them he went as assistant engineer of the Carnegie Steel Co. at Homestead, despite the fact that there had been riots at Homestead a short time previously. However, Bill was never afraid of riots, and if occasion demanded could start one of his own at a moment's notice. As a matter of fact, about the time he graduated from the School of Science one of the principal pastimes of the "schoolmen" was to engage in scraps with arts and medical men attending the University.

Currie was quite willing to live south of the Line as long as he was learning, but as soon as he got a grip of things he returned to his homeland and settled down in Hamilton, which was somewhat significant of Bill to choose the Ambitious City as his future home. Bill likes harmony and with the proper sense of the fitness of things he early realized that no better place could be found for an ambitious young man than the Ambitious City. If Hamilton were to grow as big as she dreams, there was no reason why Currie should not grow with it. At the same time he was willing to dig in, and help on the city's ambitions, while keeping an eagle eye open for the main chance, viz., himself. In Hamilton, Mr. Currie became chief inspecting engineer of the International Harvester Co., then chief inspecting engineer of the Hamilton Steel Co. After remaining with the latter firm for five years and working his way up to a responsible position he saw this company absorbed by the Steel Company of Canada. Now came Currie's great opportunity, he did not propose to work for others all his life, nor to see his plant sold over his head by promotors and mergerers, in other words, he decided to have a little company all of his own. Being a family man he knew what it was to walk the floor at nights and had so gotten into the habit that he decided that he must have a baby company of his own to keep him busy during the daytime. It took some courage as well as capital and brains to start a company that would compete and hold its own with the big corporations occupying the field in Canada. However, he waded in, organized the Canada Steel Co., Ltd., which name later was changed to the Burlington Steel Company, Ltd. He became Vice-President and General Manager of the new concern, which has now grown into a lusty youth, dropping its swaddling clothes long ago. Bill no longer has to walk the floor in the day time worrying over finances or any other matters relating to the organization, he can get away for a day or two at a time and relegate some of his duties to subordinates. As a matter of fact, he is fast developing one of the big businesses of the country, and is becoming a captain of industry, is even approaching the steel magnate bunch, although a little way behind the Carnegie and Schwab class of steel men.

The subject of this sketch is also Vice-President of the Wentworth Brass Company, Director of the Braemar Realty Co., a member of the Canadian Manufacturers' Association and the Hamilton Board of Trade. He was born at Port Perry in 1882, so that he has a good many years ahead of him in which to grow and achieve the utmost in his ambitions. That this young man deserves credit for what he has accomplished goes without saying. He only graduated from college in 1903, and seven years later organized and became head of a big steel company of his own. His is an achievement probably unsurpassed in the history of the country and, best of all, Currie has not been spoiled one iota by his success. If there were any danger of his being spoiled, we would at once publish a whole lot of things about his college days which would immediately bring him to time. "Nuff sed"!

---

The importance of mine labour doing its utmost to meet the public demands for coal was emphasized by Judge Thompson at Fernie, where the United Mine Workers appealed for the exemption of 36 coal miners. In granting the exemptions His Honor made it a condition of exemption that the applicants assist in speeding up the production of coal.

---

The operation of the American Railways by the United States Government has been attended with a rise in the value of railway stocks and bonds.

---

Coal is hauled by American railways at an average of a third of a cent per ton per mile.

FRANK CROCKARD,
Member of Executive Committee Iron and Steel Section,
Canadian Mining Institute.

W. M. CURRIE,
Member of Executive Committee Iron and Steel Section,
Canadian Mining Institute.

# Iron From the Mine to a High Explosive Shell

(A lecture delivered before the Montreal Metallurgical Association by W. G. DAUNCEY.)

Mr. Chairman and Gentlemen:

When I was asked to occupy this platform to-night two questions at once arose. First, as to the subject to be dealt with, and second as to the best method of treatment. After consideration it was decided that, owing to war conditions everyone would be, more or less, interested in tracing the production of a high explosive shell from crude materials.

In dealing with this subject we must remember that any one of the operations or processes to be afterwards described would, if thoroughly examined, take more time than is at our disposal this evening, and, as a consequence, each section can only be dealt with in a most superficial way.

It was also remembered that many members of this Society, although interested in metallurgical science, were not directly engaged in the manufacture of iron and steel, and would, therefore, be somewhat at a disadvantage, if an intimate knowledge of incidental operations were assumed.

Under these circumstances, it was decided to treat the whole subject in the simplest and most popular way, hoping that the more enlightened members would recognize the reason and be tolerant towards such elementary treatment. Few of us realize to what extent we are indebted to iron and steel and how impossible it would be to retain our present development if they were withdrawn from use.

Our means of communication, telegraphic, telephonic, and aerial; our means of transportation by land, water or air; the foods we eat; the clothes we wear; the books we read; the houses we live in, and other essentials too numerous to mention, all owe their existence to iron in one or other of its many forms. In fact, I venture to assert that if all iron could be removed from use we should return to barbarism within a single century.

It is not within the scope of to-night's subject matter for us to discuss the introduction of iron from its historical side, but may mention that its use was not general over civilized Europe until the Roman Empire was firmly established. Leaving this purely introductory matter we can at once proceed to discuss the practical side of our subject.

For this purpose I have here a sample of iron ore as it left the mine; you will notice it bears no resemblance to metallic iron, as we know it. The technical name for this type of ore is haematite, but it commonly goes by the name of "Vermillion" and is classed amongst those having an "earthly" form.

It must not be assumed that this ore will yield more than a certain percentage of metallic iron, and I am not going to deal with this which is relatively pure, but rather to generalize upon ores and their treatment, preparatory to being smelted in a blast furnace.

By "ore" we mean a metalliferous mineral as found in nature, and this is always associated with earthy and foreign matter, known as "gangue," or vein stuff.

Broadly we may say that the lowest percentage of iron that will pay for smelting must be around 33%, but some of the poorer Ohio ores only contain about 25%.

Sometimes a low metallic content is balanced by valuable fluxing qualities of the gangue, and in that case even lower percentages can be economically smelted.

It is also necessary that ores should be relatively free from phosphorus and sulphur, the reason for which will be dealt with later on.

With some ores, preliminary treatment can be avoided and the material charged to the blast furnace for smelting just as it leaves the mine. Where treatment is necessary it must be cheap and of a simple character.

Weathering, or exposure to the action of the weather, is sometimes resorted to and may extend over a period up to three years. The object of this is two-fold.

Some ores frequently carry strongly adherent shaley matter, which is difficult of removal, except by weathering, where the action of the weather, frost and air, will split the foreign matter and allow it to fall away from the ore proper.

Where an ore contains sulphur in the form of iron pyrites ($Fe\ S_2$) weathering is also resorted to and the oxygen of the atmosphere oxidizes the sulphide of iron into sulphate ($FeSO_4$) which is easily soluble in water.

We may define the dual objects of weathering as getting rid of extraneous matter, and sulphur.

Concentration is sometimes resorted to and this may be of two kinds, washing and magnetic separation, and from the latter two distinct benefits are derived: first, a considerable portion of the gangue and earthy matter is removed, which means a greater percentage of metallic iron in the remaining ore; and second, a larger proportion of the phosphorus and, sometimes, some sulphur, are thus eliminated. It is probable that when the sulphur exists as pyrites, more sulphur is removed by magnetic concentrating than by calcination.

Another preliminary operation in connection with the preparation of iron ores in calcination. This means that a material has been heated to expel any volatile constituent. It may be mentioned that misapprehension sometimes exists as to the difference in mean? ing between calcination and roasting. The former we have already defined, whilst the latter means that the material has been oxidized and it is not necessary for any portion to have been volatilized.

Broadly speaking, five beneficial results are looked for from calcination, viz: —

(1) To expel excess water.

(2) If the ores are carbonates, carbon dioxide is eliminated. This reduces waste fuel, diminishes bulk and has some beneficial influence upon the gases from the furnace.

(3) To reduce the quantities of sulphur, arsenic, and other volatile matters.

(4) By converting ferrous into ferric oxide the ore is oxidized.

(5) To remove carbonaceous matter which when present in excess tends to render proper fusion, in the blast furnace somewhat difficult.

These operations are also carried out in various types of furnaces and ovens, as well as in open piles or heaps.

We have now seen that some iron ores, after leaving the mine, are subjected to a preliminary treatment before being charged to a blast furnace.

A blast furnace, in which ores are smelted and where we get the first appearance of metallic iron, is a vertical cylindrical steel shell, lined with fire brick and other refractory materials. The internal shape varies and each cross sectional zone has a different diameter. In the walls of what is termed the hearth, near the bottom of the furnace, are pieced holes, through which the necessary blast, or air, to support combustion, is introduced.

A modern blast furnace may reach to a height of 100 feet or more and may be described as a vertical iron or steel structure lined with varying thicknesses of fire brick; closed at the bottom, with the exception of the blast apertures, the slag notch and tapping hole.

At the top a mechanical contrivance for feeding fuel, ore and flux is arranged, and also an opening for the escape of gases and waste products of combustion.

The approximate dimensions of a blast furnace as in use at the Edgar Thompson works are a maximum outside diameter of 30 feet and inside diameter of 22 ft., the diameter of the hearth 11 ft, of the charging bell 12 feet, and the throat, 15 ft. 6 in. The height is 80 ft. and the cubic capacity 18,200 ft.

The blast necessary for combustion is delivered at the rate of 25,000 cubic feet per minute, enters through seven twyers at a temperature of around 1100° F., and a pressure of 9 or 10 lbs. per square inch.

In the early days of blast furnace history, it was usual to leave the top of the structure open for the escape of gases and products of combustion, but it was soon realized that this was uneconomical and resulted in great loss of heat.

To supply this quantity of air, heated to the necessary temperature, various types of stoves, regenerative and otherwise, have been designed, but for our purpose we need only remember that, before entering the blast furnace, the air is dried, heated and put under pressure.

As regards the working of a blast furnace, and the resultant production of metallic iron, we may divide the subject into three parts:

(1) Charging materials.

(2) Reactions taking place, and operating the furnace.

(3) Tapping the molten pig iron and slag.

It would be interesting to take the chemical analysis of the ores, fuels and fluxes used in a charge, to follow the materials through from raw to finished product, noting the various reactions and chemical and physical changes as and when they occurred. This would, however, be beyond the scope of our examination and the time at our disposal will not allow detailed treatment for any section.

To those who are familiar with the massive structure of a blast furnace only from its outside appearance, the fact that every thermal and chemical reaction is nicely calculated, closely watched and results confidently anticipated, may be somewhat of a surprise. The day of rough and ready metallurgical manipulations is fast becoming forgotten and definite laws, established practice, and chemical knowledge are the factors which tend to produce a uniform and reliable material.

We have seen that the ore in its native state required some treatment before being charged to a blast furnace, we know the nature and object of that treatment. It has also been shown that a blast furnace is an enclosed vertical chamber, with an inlet at the top for raw material and also an outlet for gases; and that at the bottom, above where the metal when molten will lie, there are a series of seven or eight air inlets and below a hole through which the metal will be tapped.

It is now necessary to consider the putting of such a furnace to work, or as it is technically known, "blowing in." The first step is to thoroughly dry out the brick lining, for however carefully bricks may have been laid the joint mortar and slurry contain water which must all be evaporated before a furnace can be thoroughly dry. This drying can be achieved either by burning a wood fire or by inserting gas burners.

Considering the vital importance of avoiding cracks or openings in the lining, this drying should be gradually effected, and it is probable three weeks is never too long a time to make a satisfactory job.

Having dried out, the next operation is to make a bed or bottom strata, which must continue well above the air inlets, or twyers, because no melting of raw materials can take place below this level.

The bed being prepared, the charges of fuel, ore and flux are commenced, but at first the fuel ratio is kept much higher than when the furnace is in operation. This ratio is later gradually reduced until between 10 and 15 days, when the burden should be normal.

The furnace is lighted through the twyers and a light blast turned on; soon after this slag begins to accumulate in the hearth and a little later iron comes down as well.

The first iron down generally is "off" because temperature and chemical conditions are not yet properly established.

We now get a continuous cycle of operations, an alternate feeding of fuel, ore and flux (limestone), a descending of this mass to take the place of fuel consumed and iron tapped from the bottom of the furnace.

So much then for the "blowing-in," and charging of a furnace, and we will now glance at what takes place during the operation.

We have four factors to consider, viz.: ore, fuel, flux and air. Taking the ore first, the oxide of iron is reduced, the metal combines with carbon and other elements and runs down to the hearth; the earthy matter combines with the fluxes, making a fusible slag which also runs to the bottom.

The fuel consists of carbon (if raw coal is used, all volatile matter has been driven off before combustion takes place) and air coming into contact with this heated element at once burns it to carbon monoxide, thus,

$$C \times O = CO.$$

If any carbon dioxide ($CO_2$) is formed it is again at once reduced to monoxide by the excess carbon.

Now carbon monoxide thus formed will require twice

the space the oxygen consumed would have required. We thus get:

100 volumes of air=(79 volumes of nitrogen
(21 " of oxygen.

will form 121 volumes of gas containing.

42 volumes of carbon monoxide ($CO$.)

If the air were dry we should then have ascending gases containing 34.7 per cent of carbon monoxide.

Whatever ore is charged the iron must be an oxide (either $Fe_2O_3$ or $Fe_3O_4$) because calcination has converted other components to this form before charging.

The descending charge from the top of the furnace comes in contact with ascending gases at around 600° F. and the carbon monoxide attacking the oxide of iron reduces the iron thus,

$$Fe_2O_3 \text{ plus } 3\,CO = 2Fe + 3CO_2$$

some carbon dioxide taking the place of the monoxide in the gas.

This reaction commences at a low temperature, at or near the top of the furnace and becomes more rapid at lower levels where higher temperatures, prevail.

By the time the descending charge has attained a bright red heat any $CO_2$ formed will immediately be reduced to 2 CO, on the other hand solid carbon from the fuel may act on the oxide of iron forming carbon monoxide thus, $Fe_2O_3$ plus $3C = 2Fe \times 3CO$. Whichever happens the result is practically the same, each 56 parts of iron reduced absorbs 12 parts of solid carbon.

Losing carbon thus means a loss of fuel, for if it were not consumed in this way it would be burned at the twyers and increase the heat required in the furnace.

This is sufficient to give in outline some idea of what goes on inside a blast furnace, but it must not be assumed that all ores behave in exactly the same way.

We have next to consider the influence of the limestone flux; this always varies with the amount of veinstuff to be fluxed away and with furnace working conditions.

For an ordinary haematite, with silicious gangue, or vein-stuff, each ton of iron obtained will require about 10 cwts. of limestone. In descending in the furnace, the limestone is decomposed thus,

$$Ca\,CO_3 = CaO \text{ plus } CO_2.$$

Starting at a dull red, this reaction reaches its maximum at a bright red, but at this temperature carbon dioxide it attached by carbon, so that $Co_2$ liberated by the above reaction becomes reduced to $CO$ and as such passes out of the furnace.

The essential function of the limestone is to combine with the impurities which are present, in order to form a fusible product, known as slag. Many interesting details of slags and the influence they exert must be omitted.

Similar reactions occur with other elements, such as silica, manganese, phosphorus and sulphur, but they cannot be examined here.

At the top of the furnace we had the raw materials being charged; we have some knowledge of what has taken place during its descent and we now have molten metal covered with slag lying in the hearth of our furnace. This is now withdrawn into ladles and from these cast into pig molds.

In examining one of these pigs we observe the first indication of metallic iron; instead of the stoney looking ore that was charged we now have a material made up of bright grains, showing a highly crystalline fracture, and known as pig iron.

Roughly, this material will contain around 90% of metallic iron, with the balance made up of carbon, silicon, sulphur, phosphorous, manganese and copper, the latter probably only as a trace.

To summarize what has been so far dealt with, we now know that iron ore, fuel and flux brought together under proper thermal and chemical conditions, produces metallic iron whilst the earthy and other deleterious matters are separated out.

Endless interesting details regarding both pig iron and slags must be passed over, or other sections of our subject will not be even touched, but it should be said that by merely balancing the elements in all the materials used, and by working with known conditions of blast and temperature, it is possible and usual to produce an iron to within very close chemical specification limits.

At this stage of our examination it will be necessary to show how, by varying the treatment, all kinds of finished iron and steel are manufactured from the product of the blast furnace.

| | | | |
|---|---|---|---|
| Ore | Pig Iron | Re-melted | —Ordinary gray iron castings. |
| Fuel | | Re-melted | —White iron castings for malleable work. |
| Flux | | puddled | —For merchants or wrought iron. |
| | | blown | —Bessemer steel. |
| | | melted | —Open hearth steel. |
| | | melted | —Electric steel |

A reference to the diagram will illustrate this point.

Having shown that melted together under certain conditions, iron, ore, fuel and flux produce pig iron, we can follow our material and see the nature of the processes used to convert it into all types of finished iron and steel.

By re-melting the pigs in a cupola furnace, we get the ordinary gray iron castings of commerce, and these may have a very wide range of chemical composition, brought about by mixing different grades of pig, by casting temperatures, by artificial or natural cooling conditions and by the type of mold used. Roughly, we may claim that the ease with which we may machine this type of metal is brought about by the presence of silicon, but we cannot stop to consider this in detail, nor yet to show that the presence of silicon influences, not the quantity, but the form in which the carbon exists in the casting.

The second process indicated on our diagram is one in which the pig iron is melted in a cupola, air-furnace, or open hearth, but cast as white instead of gray, iron. Silicon is the element responsible for this difference in physical structure; in the gray iron practically all the carbon existed as free graphite between individual grains, but in white iron the carbon is chemically combined according to the formula ($Fe_3C$) and is the hardest-iron-carbon compound we can produce. It may be asked why the iron founder produces a metal of this character and one which cannot be cut in any way or machined. The answer is this: where it is desired to afterwards heat treat cast iron, with the object of rendering it malleable, the carbon must be, at

the commencement of the operation, in the combined form, otherwise annealing will be detrimental, instead of beneficial.

The process of converting pig iron into malleable cast iron is to melt, as previously explained, in the cupola, to cast in ordinary green sand molds, and then to anneal.

American black heart malleable is made in this way, the hard castings being packed in hammer scale, or some similar material, and then heat treated for periods varying with the section of metal to be malleableized.

What happens can briefly be summarized as follows:

The hard white casting, with its combined carbon, is heated to from 1500° to 1650° F., and kept at this temperature for from 40 to 60 hours. The effect of this is that the massive carbide plates ($Fe_3C$) break down and liberate the carbon, which remains in the casting, but in the form of graphite, or temper carbon. A certain percentage of the carbon is oxidized and lost, but this is accidental and is not the object of the process.

The European, or white heart malleable, is cast and prepared in the same way, but is packed in an oxidizing material, is heated to a higher temperature and for a longer period, with the result that the carbide plates are broken down more effectually and most of the carbon is oxidized and migrates.

Thus, although, both materials have about the same initial carbon content, the American finishes with only a slight decrease, whilst the European loses its major portion.

We have now seen that from coarsely crystalline cast iron we can produce a material malleable in nature, capable of withstanding shock, even better than steel, and one that by heat treatment has been completely changed in all its physical characteristics and partially changed as to chemical composition.

Had malleable iron manufacturers devoted more time and attention to improving the standard of their product, steel would never have taken its place for so many purposes.

Where shock has to be withstood, good malleable iron will always prove superior to steel. This point is capable of every proof and demonstration, but time will not permit us to enter into details.

Our diagram next shows that wrought iron is also a product of pig iron, and we shall now examine the process by which such a total change in physical characteristics can be brought about.

Taking pig iron, it is introduced into a reverbratory puddling furnace, in which owing to the intense heat necessary towards the end of the operation, the grate area is large in proportion to that of the hearth.

This puddling process was the invention of one, Henry Cort, in 1784, but modern practice has made two most important changes. The inventor used white pig iron, which remained in a pasty condition during the process, and the bottom of his furnace was of sand. To-day oxide of iron is used for bottoms and the pig iron is gray, with a composition around:

Carbon—3.5%.
Silicon—1.0 to 1.5%.
Phosphorous—.5%.

About .6 of this carbon is combined and the balance graphite.

For our purpose it is not necessary to examine methods used for refining this iron, although the elimination of silicon and partial elimination of phosphorous and sulphur are interesting subjects.

Preparatory to puddling a charge of iron, the furnace bottom is covered with a layer of refractory material, rich in oxide of iron, to a depth of about three inches. This is heated just enough to soften it. Upon such a foundation clean scrap is placed and raised to a welding temperature, then made into a ball and well worked over the bottom. By this means all spaces, or cracks, become filled with magnetic oxide and a solid hearth is obtained. The sides are then made up with the same fettling and the furnace is ready for work.

Tap cinder, consisting of:

Silica
Ferrous oxide
Ferric oxide
Manganous oxide
Alumina
Lime
Magnesia
Sulphide of iron (Fe S.)
Sulphur
Phosphoric acid
Iron

(The iron content runs from about 40% to 58%), is put in so as to form a bath for the iron pigs, broken into two or three pieces for greater convenience in handling, are charged, the working door closed and the fire hole stopped with slack.

It may be well to divide the process into five stages, so that we may clearly understand how and when the physical and chemical changes take place.

(1) **Melting Down.** Owing to the high temperature the pigs soon begin to soften. During this stage the puddler pulls all unmelted portions towards the centre of the bath and as soon as everything is melted, he vigorously stirs or rabbles the charge. The regulating damper is lowered and the temperature somewhat reduced.

(2) **The formation of slag, or silicon oxidation.** At this stage, the molten metal is completely covered with slag and lies quiet. From time to time the slag is mixed up with the metal, and hammer scale, or other highly oxidized material, is introduced to increase the oxidizing power of the slag.

(3) **Carbon oxidization, or boil.** It now appears that the bath is boiling, this being due to the evolution of carbon monoxide. During this period the puddler keeps his slag well mixed in with his metal.

(4) **Final oxidization, or removal of impurities.** As the boiling diminishes, the iron stiffens up and becomes much more difficult to work; much of the slag has boiled up and escaped from the slag hole, whilst what remains is quiet, and allows the iron to be seen as a mass of bright granules. During this period temperature and stirring are forced to the utmost and the iron gradually "comes to nature." A close examination reveals an aggregation of malleable iron granules.

(5) **Balling up.** The charge is now only slightly coherent and is easily broken up, with iron bars, into lumps or balls of from 100 to 120 lbs., which are lifted from the furnace and are then ready for the next operation, known as shingling.

Two products result from this process: puddled bloom and slag. The bloom consists essentially of

granules of malleable iron, and contains much trapped or included slag, which is largely removed during subsequent operations. The contents of the cinder have already been given.

As puddling, or the conversion of pig into malleable iron, depends essentially upon the oxidization of impurities, there must of necessity be a loss of weight and this will be increased by iron passing into the slag, as silicate, or oxide. This loss probably runs around 10 or 12%, and the process itself is particularly wasteful; the furnace hearth is short and gases escape at a very high temperature.

Most of the reactions incidental to the process evolve heat, so that the chief function of the fuel is to maintain temperature, yet the amount of coal used will sometimes reach 27 cwts. per ton of iron produced.

We now have a spongy mass of iron granules containing quantities of still fluid slag, and the next operation:—

### Shingling.

which is of a dual nature, is to consolidate the metal and expel the slag. As rapidly as possible, the ball is removed to some mechanical contrivance such as a hammer, or squeezer, where it is shaped into a roughly rectangular slab, and then passes to the rolling part of the operation, to be reduced to some convenient size of bar or billet.

This puddled bar is malleable iron, breaks with a crystalline fracture and indicates lamination and fibre. The included slag and oxide exist in comparatively large portions and have, by the rolling, been extended in the direction of their length. Whilst passing through this operation large quantities of scale are formed, which consist entirely of iron, approximating the composition of the magnetic oxide ($Fe_3O_4$). The slag forced out contains quantities of silica and phosphorus.

The puddled and shingled bar now passes to the mill for further treatment to convert it into "merchant bar."

By means of shears the bars are cut into lengths of from 12 in. upwards, piled up, bound round and are then ready for the mill or reheating furnace. This furnace, somewhat similar in outward form to the puddling type, is small, reverbertory and with less proportionate grate area. The working bottom is sand, with a quick slope towards the chimney base. This arrangement is adopted so that whatever slag forms runs away from the hearth and the piled iron.

The charge having been brought up to a good welding temperature, the piles are ready for removal and then pass directly to the rolls, where they are shaped to some form of merchant bar.

Certain changes take place during this operation, much of the included matter is removed, the slag and phosphide of iron sweat out and more is forced out during rolling. Owing to the oxidizing influence of the atmosphere, some carbon and silicon are removed and the phosphorus is also considerably reduced.

For "best best" and "treble best" iron the operation of piling, re-heating and rolling is sometimes repeated several times.

The material at this stage of our examination would, if nicked and broken, show a fibrous structure; the fibre depending upon the quality of the iron and the amount of work that had been put upon it. It is sometimes supposed that this fibre is due to the elongation of the iron crystals, but this is erroneous.

We have already seen that a certain amount of slag remained in the shingled bloom, and this was, relatively in large masses. The effect of work has been to break up these masses and the rolling action has tended to elongate them in the direction of their length, producing thread-like filaments, which show up as fibre in newly fractured malleable iron.

We have now studied how from iron-ore, fuel and flux, pig iron is produced; how from pig-iron we get gray and white iron gastings and how the latter are converted into malleable castings. Also we have seen how pig iron, by the process of puddling, shingling and rolling is changed into wrought, or malleable, iron, and we can now consider the first portion of our subject as finished.

In the second section we shall try to show how from the same materials, we are able to produce every known grade of steel; how difference in manufacture, varying chemical composition and methods of treatment will account for the innumerable varieties of physical characteristics, to be found in material all classed under the common title of steel.

Taking the more important processes, we have:

Crucible,
Bessemer,
Open hearth, and
Electric.

The first is older than either of the others, but like them can be classed as an indirect method, that is, the steel is produced from some product which was, in turn, produced from iron ore.

It was in 1740 that Huntsman (a native of Sheffield, England) began to make steel in a crucible, from blister bars (these blister bars were the product of a cementation process) and the steel makers of Sheffield to-day follow the inventor's methods, maintaining that puddled iron will not make as good a steel as the charcoal product.

It is difficult to understand why weeks should be devoted to carburizing iron bars by a solid solution method and then breaking and melting them, when the two operations can be simultaneously completed in a few hours.

On this side of the Atlantic makers pack their crucibles with soft iron and charcoal and obtain a steel of the desired temper in a few hours. Puddled iron with low percentages of sulphur and phosphorus will produce a tool steel equal to anything that can be made in any other way.

The crucible method of manufacturing steel is carried out in a variety of furnaces, including anthracite and coke holes, oil fired and regenerative gas, of both American and German types, etc.

Whatever furnace may be used, the idea is to melt certain materials in a covered crucible, so as to produce steel of a given temper.

Crucibles, or pots, may either be made of a mixture of clays or plumbago, and are provided with stools and covers. A good mixture is 30% new clay, 50% burnt clay and 20% coke.

The furnace, or hole, being thoroughly dried out, and the fire low, stools are introduced and upon these two pots and covers are placed. When these have become white hot, sand is thrown in and this frits and holds crucible and stand together.

The material to be melted, after being carefully selected and weighed, is charged through a funnel, the lid adjusted and the hole filled up with coke. The process of making crucible steel may be divided into

two stages, melting and killing. The coke will have to be replenished two or three times and melting will take from two to three hours. By the time this stage is completed the metal moves and acts in the crucible as though slowly boiling, and brilliant specks of metallic iron appear upon top of the slag. The metal is not yet fit to be poured and in this condition would make castings full of blow holes and generally unsound. To prevent this, it is held in the crucible until "dead melted," or, as it is technically known, "killed."

It is now ready and may be poured into separate molds, or if large sections are required, several crucibles may be turned into a ladle and from there transferred to the mold.

The melting loss is very small, around 2%, and with light charges the best of material, and skilled melters it is the ideal process for the production of small quantities of specially high grade or alloy steels.

Crucible steel making is essentially a melting proposition, but certain chemical changes take place. The metal will always carry oxide of iron; air in the crucible will yield its oxygen to form oxide of iron, and this combined with the silica of the pot will form silicate. The metal may pick up silicon from the clay and carbon from either coke or graphite. If carbon is high less silicon will be removed. Manganese protects the silicon because it oxidizes first and by so doing uses all the available oxygen. Carbon and silicon are almost always increased during the melt, but manganese is reduced.

Pyrites in the clay, or furnace gases, invariably increase the percentage of sulphur.

We can now examine the process invented by Sir Henry Bessemer in 1850, and known under his name. This consists essentially of blowing air into and through a molten mass of pig iron, which must have high percentages of carbon, silicon and manganese. The operation is carried on in a cylindrical vessel closed at the bottom, but with an open throat or neck. This is supported on trunnions, one of which is hollow, to act as a blast main, and by various mechanical devices can be rotated through a complete circle. Innumerable modifications of the original convertor design have been introduced, but the fundamental principle remains the same.

A charge of molten pig having been run into a convertor and blast turned on the oxygen of the atmosphere attacks the silicon, carbon and manganese at once, forming silica and oxide of manganese, which unite with oxide of iron (the latter produced by the oxidation of a portion of the bath) to form a slag; while the carbon escapes as Co, and burns, with a vivid flame at the convertor mouth, to $CO_2$.

After a lapse varying from 8 to 15 minutes, the impurities are all oxidized out and the iron itself begins to burn with the production of a large amount of iron oxide, some of which is absorbed, whilst the balance enters the slag.

The burning of carbon to CO increases the temperature of the steel slightly. It is by the heat due to oxidization that the molten bath is kept hot and fluid after the impurities are burned out. Recarburizing is then resorted to and the metal cast in one or other of the usual methods.

This also, like the crucible, is an indirect method of making steel and its advantages may be enumerated as:—

(1) Light cost of initial installat on.

(2) Relative cheapness of metal produced.

(3) Large tonnage in proportion to invested capital.

(4) Fluidity and high temperature of product.

(5) The adaptability, or the fact that the process lends itself to intermittent working.

(6) In small plants numerous heats can be taken at short intervals.

The disadvantages may be summarized as:—

(1) Inferior quality, the metal not being as good as crucible or electric, which are its closest competitors.

(2) Small heats, not always convenient or economical.

(3) Inability to produce different kinds of steel in small lots.

The only way is to add molten carburizers to different ladles and then add varying amounts of the blown steel.

If the slag made chances to be sticky it is easy to hold it back at the convertor mouth and to weigh exact amounts of steel, but if the slag is fluid it is impossible to accurately obtain this result.

It is usual to make both acid and basic steel in a Bessemer convertor, but as a comparison will be made between these as carried out in an open hearth furnace, it was not necessary to consider both processes under the head of Bessemer steel.

The open hearth method comes next in our examination, but easily ranks first in importance. The furnace in which this operation is carried consists of a hearth hollowed or basin-shaped, regenerative chambers, valves by which the in and outgoing gases can be regulated and a stack in area and height sufficient to induce a good draft.

Originally producer gas was the only fuel used, but natural gas and fuel oil are now largely resorted to and in many works experiments are being tried with powdered coal.

Broadly, whatever the fuel and whatever the details of operation, the conditions existing in an open hearth furnace are very much alike.

Above the platform level, the hearth, or furnace proper, is constructed and as, with the exception of the internal bottom, the same materials and design are adopted, this description will equally apply to both acid and basic manipulation.

The hearth is rectangular in shape, depressed from all points towards the tapping hole and open at both ends for the admission and escape of gas, air the products of combustion. It is arched with a roof of 9" or 12" firebricks, tied together with buckstaves, plates, rods and brackets.

The working platform, or stage, is constructed of plates rivetted to rolled girders and supported either upon side walls, or cast iron columns. A space is left between the under side of this and the brickwork, to allow a free circulation of air, which helps to keep the bottom of the furnace cool. Besides this, the expansion of the regenerators is so great that perfect freedom of movement is necessary to take care of this movement. The regenerative chambers are brick built, red outside and lined one course firebrick, well supported with buckstaves, girders and tie-rods.

It is to these regenerative chambers that the open hearth, or Siemens, furnace owes its value. They are filled with a checker work arrangement of firebricks, in other words, the bricks are stacked alternatively in both directions of the chamber and with openings between every course. Flues connect these chambers

with the hearth and also with the stack and by an arrangement of valves each regenerator can either admit or exhaust gas, air and products of combustion. The whole structure, including regenerators, flues, etc., having been well dried out, the operation of the furnace is as follows:

A good fire is kept burning, and gas and air, or oil and air, are admitted at one end of the furnace, pass over the hearth and escape through the opposite ports, then down through the regenerative chambers and outlet flues to the stack. In this passage over the checkers, much of the heat of the escaping gas is absorbed by the bricks and they become incandescent. This may be termed the storage of what otherwise would be lost heat. After a period of from twenty to thirty minutes the valves are reversed and what was an inlet regenerator becomes an outlet regenerator, and vice versa. The incoming gas, or air, now takes up heat from the incandescent bricks and carries it back on to the furnace hearth, where, after doing its work, it escapes through the opposite generators, again giving up its heat to checkers. By thus generating, collecting and re-using of heat, it is possible to get the necessary temperature upon the hearth, which would not be possible by the straight burning of coal.

There are three methods of producing steel in one of these furnaces, but as two are modifications of Sir William Siemens original invention, it will be sufficient for us if we examine one only:

(1) By treating pig iron (non-phosphoric) and certain iron ores, without the addition of scrap, or other material. This is the direct way, as first adopted by the inventor.

(2) The fusion alone of a mixture of pig and scrap iron or steel, which is known as the Siemens-Martin process.

(3) By a combination of both the above methods, by treating pig-iron, iron or steel scrap and certain pure iron ores together.

It may be said that the process consists of three stages, viz:

(1) Melting.
(2) Oreing.
(3) Recarburizing.

Owing to the heat of the furnace from a previous charge it usually is not long before the material begins to melt and when all is fluid iron ore is added, until the oxidizable constituents have disappeared. In some cases all the carbon is removed and in others a suitable amount for the grade of material required is allowed to remain.

The pig iron is first to melt, sometimes leaving the outside sand covered shell behind to come down with the scrap. During this time the oxidization is very vigorous and about five hours will be required for a 30-ton heat. It is probable that during the melt about 50% of the carbon and nearly all of the silicon and manganese are oxidized. By the time the metal is fluid it will be covered with a layer of slag, which helps to check too rapid oxidization.

Oreing is now commenced. If the oxidization has been sufficiently vigorous to remove most of the silicon during melting, the boil will commence at once, but if this has not been so, there will be a preliminary period of slag formation, during which the metal is coming to the boil. We must assume that the ore ($Fe_2O_3$) is a mixture of two parts of iron oxide and one of oxygen. The iron oxide will combine with the silica formed by the oxidization of the silicon by the oxygen and will pass into the slag.

The removal of carbon is slow at first, but gets more rapid when the boil begins and it is an inability to realize this that causes some melters to get away down on their carbons, even after an intermediate test has shown about right. Silicon is rapidly removed from the beginning; the iron oxide carried into the molten pig by the oxidized scrap, and, later by the ore, ensures its removal.

Manganese is oxidized readily in the early stages of the working, but if there be much it may unduly prolong the process and lead to a large consumption of ore. Practically no sulphur is removed, although it is probable some slight elimination takes place as sulphur dioxide. No phosphorus is ever eliminated, the whole remaining in the steel.

Some iron is oxidized and passes into the slag, but this is practically balanced by that gained from the reduction of the ore. The slag just before tapping would analyze:

Silica
Manganese oxide
Ferrous oxide
Manganous ferrous oxides.

For this a wider range of pig iron can be used than would be permissible with the Bessemer process, and practically any kind of scrap may be used, provided the phosphorus and sulphur are within allowable limits.

The heat being finished it now only remains to recarburize the tap. The term "recarburize" is somewhat misleading, because the adding of carbon is only one of the objects, of which there are three:

(1) Removal or neutralization of gases and oxides retained in the bath.
(2) Introduction of metals.
(3) Regulation of carbon content.

After a heat is finished, with the exception of adding the recarburizer, it is found to contain certain oxides of iron and other metals, as well as gases (oxygen, hydrogen, nitrogen and carbon monoxide). Unless these are removed, or neutralized, the metal will be wild with frothing and bubbling in the ladle and molds. Then a specification may call for a manganese content of around .75% and we have seen that the entire amount of manganese contained in pig and scrap has been oxidized, so that we must add manganese.

And, finally, whether our carbon has been caught coming down, or been entirely oxidized, we must adjust the percentage in accordance with our specification demands.

From these statements it will be seen that recarburizers perform other functions besides supplying carbon.

Amongst the various "recarburizers" may be mentioned ferro-manganese (an alloy of manganese, carbon and iron=about 80% manganese) speigeleisen, (the same as ferro-manganese, but with under 20% manganese) ferro-silicon (a very high silicon pig iron) silico-speigel (a combination of speigeleisen and high silicon pig having the high manganese of the former and the high silicon of the latter.)

The above enumerated alloys are all the product of a blast furnace, running on special charges, but another —silicon carbide—is produced in an electrical furnace.

The addition of a recarburizer can be effected either in the furnace just prior to tapping, or in the ladle and

sometimes the heavier portions of the material are fed to the former, whilst the lighter goes to the latter.

Without entering into details, sufficient has been said to show that the manufacture of open hearth steel is a nicely balanced chemical and thermal proposition.

The chemist arranges the relative proportions of the materials charged, and the melter watching his furnace conditions, temperature, nature of slag, etc., etc., and by taking, cooling, and breaking a small sample of the steel, judges how the reactions are progressing.

In my experience I have known melters who would run a furnace for months with a variation of only a few points on any chemical element in their metal.

All that has been said about the design, construction and operation of an acid open hearth furnace applies equally to one intended for basic steel, and it is only in the materials charged and composition of the furnace bottom that essential differences exist.

It has been shown that for acid work, the stock used must not contain more phosphorus than can be allowed in the finished steel, but this condition ceases to exist where a basic furnace is being worked.

The oxidization of carbon, silicon and manganese follows the same laws, but the addition of lime and the consequent forming of a basic slag mark a material deviation from acid practice. The use of a basic slag is rendered possible by a change in the furnace bottom, instead of having it of silica sand, basic magnesite is employed. If an acid sand bottom was used with a basic slag it would immediately scour away.

Essentially this is a process for the removal of phosphorus and within wide limits the percentage is immaterial. The chemistry of the process may be outlined as follows:

**Phosphorus**: $2P{=}5O{+}P_2O_5$, in other words, the oxidizing influences of the flame and ore have produced phosphoric anhydride from the phosphorus, which in turn in the presence of lime, form a phosphate of lime.

**Sulphur.** Some of this element is removed as a sulphide of calcium ($CaS$) by manganese in the ore, and by metallic manganese, forming manganese sulphide ($MnS$).

**Lime.** This may be used either as limestone ($CaCO_3$) or calcined as $CaO$, the latter having had its carbonic acid gas driven off. If limestone is used calcination takes place in the open hearth and the volumes of $CO_2$ thus liberated make the bath boil with the production of lively reactions. The $CO_2$ is also an oxidizer, and where raw limestone is used more pig can be used and more metalloids oxidized.

The followin gthree reactions will explain the oxidiation:—

Carbon $C + CO_2 = 2CO$

Silicon $Si + 2CO_2 = 2CO + SiO_2$

Manganese $Mn + CO_2 = CO + MnO$

For this work the pig must be comparatively low in silicon (under 1%) because a greater percentage renders the slag heavy and to obviate this condition large quantities of lime must be used.

From 90 to 100% of phosphorus can be eliminated from the charge and removed in the slag.

These are the main differences between acid and basic practice, and if time permitted it would be interesting to make a comparison between the physical characteristics of each material, for marked differences exist. One point may be mentioned in connection with the specification for shell steel. Carbon is specified as between .40 and .60, so that the metal is classed as medium high, but to get the same physical results from basic steel, one must have about five more points of carbon than would be necessary with acid steel.

Manufacturing steel in an electric furnace is the last on our list and will have to be dealt with in a very superficial way. Many advantages are claimed for this method, and the chief one probably is that by it phosphorus, sulphur, oxides and gases can be eliminated more perfectly than by any other method. This is due to the absolute control exercised by the operator over his working conditions, which he can make oxidizing, neutral, or reducing at will. Such a statement causes one to wonder why steel makers have not universally adopted the process to the exclusion of all others.

The reason is one of cost. We can make eléctric steel more cheaply than crucible, but cannot compete when working with cold stock with Bessemer or open hearth metal. There are no limitations, the process can be operated to produce every grade of special steel, alloys can be added, baths brought to temperature and held for an indefinite period, without radical chemical changes occurring and without appreciable loss of our alloys.

The electric furnace is almost always run with a basic lining so raw material need not be low in phosphorous or sulphur, and as the elimination can be carried to any extent it is possible to re-use all domestic scrap without fear of these elements running above permissible limits.

Notwithstanding the flexibility of the process, the true function of the electric furnace is the final refining of steel and wherever possible, the melting and eliminating of carbon, silicon, manganese and the major portion of the phosphorus and sulphur should be done in some other furnace.

We have glanced at the various methods in use for producing steel and can now consider the tapping of a heat and the production of billets, to be used for high explosive shells. By the crucible process manual labor has to be used to lift pots from their holes, with Bessemer steel the convertor is rotated to pour the metal into a ladle, and with open hearth, a tapping hole is broken out in front of the furnace and the fluid steel allowed to flow along a spout into a ladle. The ladle may be described as an iron or steel bucket suspended by trunnions and a bail to an overhead crane. It it lined with firebrick, ganister, and other refractory materials and slopes in all directions on the bottom towards an opening. This opening may be of various sizes and is formed by a fire clay nozzle, into which a stopper fits. The stopper is of graphite and forms the termination to an iron rod, which is encased in fire clay sleeve bricks and actuated by a lever from the outside. The molds used are of every imaginable design and of cast iron. Molds to cast a billet to make two shells have been tried, others were hexagonal, roughly square, and tapered, but the best results will always be achieved by a mold that gives a smaller cross sectional area at the bottom than at any other point. This is accounted for by the fact that under such conditions the metal first freezes at the base and then gradually freezes upwards, driving occluded matter and gases up into the head, which is the part remaining fluid longest and afterwards discarded as waste.

These molds may be open at the bottom, in which case they are set up on stool plates, sometimes with an intervening thickness of paper to make a good joint, or they may be solid bottomed. Whichever type is

used they are set up on the foundry floor and the metal having been tapped from the furnace into the ladle, the latter is brought over the molds, the operating lever lifted, the stopper raised and the steel allowed to flow into a mold. When this is filled the ladle travels to the next mold and so on until the whole heat is poured. The ladle man requires to exercise skill and judgment in opening and closing his nozzle, otherwise he may produce ugly and dangerous surface coldshuts and blown or spongy ingots. After solidifying and when at a dull red heat the billets are removed from their molds, allowed to cool off, then superficially inspected and passed to various types of cutting off machines. Here a discard with a minimum weight equal to 20% of the total weight of the billet is removed and the billet, with a newly exposed fracture, goes to the inspection tables. A lot of unnecessary friction has arisen during inspection, caused, primarily by the inability of the Imperial Munitions Board to secure men experienced in steel matters. Many of the men employed on this all important work were totally untrained and were brought in from every conceivable walk of life. This was a situation alike unfair to the inspectors, to the steel makers, to the forgers, and to the Munitions Board, who were always driving for greater production.

The billets having passed inspection are ready for forging, previous to which they are heated in some form of furnace to a temperature around 2150° F.

Uniform heating and thorough soaking are two essential points that must be observed, if satisfactory forgings are to be produced. The forging presses are massive structures, hydraulically operated, with a decending plunger, which travels down the centre of a fixed die pot. The heated billet is placed in this pot and the plunger descending with a pressure ranging from 200 to 500 tons, perforates the steel, at the same time forcing the plastic metal upwards, within the annular space between plunger and pot. This results in a hollow forging of increased length and practically concentric form.

After further inspection, this shell is machined inside and out the base recessed and a strengthening plate inserted. The head is then contracted to form a nose, a copper band is compressed into position near the base end and the machining finished. This work is all done under rigid inspection and to conform to precision gauges, as to shape and size and the finished weight also has to be within very narrow limits.

So much then for the operations incidental to the conversion of iron ore into a finished shell. We have followed all the physical, chemical and thermal operations and should have a good general idea as to how and when the various changes have taken place.

I may be allowed to repeat a statement and emphasize the fact that the smallest operation alluded to would supply ample matter for an evening's consideration, if dealt with in detail. Frequent references have been made to the chemistry involved at every step, but nothing has been said as to the metallographer, or physician, if I may use the word. The chemist takes his sample, splits it into its component parts and then gives an analysis report, which accounts for, within a few points, every particle of the sample he had under treatment. He will tell you he found certain percentages of various elements, but he cannot tell you in what form they existed in the metal and it is here that the value of metallography appears. By this latest aid to our knowledge of metals and minerals we can discover in what form or combination of forms each element exists, and when we remember that an element in one form may be harmless, whilst absolutely dangerous in another, we can at once realize the valuable aid the physical analyst can give to the manufacturer and user of metals.

The class of work, thermal treatment and a variety of physical characteristics can all be identified and made use of when the material is subjected to a discriminating microscopical examination. A glance over a wide field, such as we have taken to-night, opens up endless subjects for study and research and, in the event of my efforts having met with your approval, I shall be glad at some future time to take any individual operation, or process, and devote a whole evening to dealing with it in detail. Your President might like to select the particular matter to be dealt with.

## NEW COMPANY.

### Strong Efforts Were Made by Montreal to Get It.

Having interested considerable outside as well as local capital C. W. Kirkpatrick, commissioner of industries, was able recently to announce the reorganization of the old Wentworth Brass Company. The new concern will be known as the Wentworth Manufacturing Company, and will carry on an extensive manufacturing business in the premises of the old concern, Oak avenue.

The capitalization of the new firm is placed at $300,000. While there will be no immediate extension, indications point to some in the future. The plant will shortly be in full running order. The Wentworth Brass Company manufactured electrical and gas fixtures. The new company will specialize in certain essentials, such as nickled tea kettles, teapots, brass jardinieres, nickled hinges, casseroles and lawn sprinklers. The bank has been carrying on the business of the old concern in a small way since that company went into liquidation.

The new company will introduce an automatic department to manufacture high grade screws and bolts of nickel steel, principally for use in the construction of aeroplanes.

A determined effort was made to land the new industry for Montreal, and it was only after considerable negotiation on the part of the commissioners of industries that Hamilton was decided upon. J. J. Nells will be manager and William Beattie, a Hamilton man, will be shop superintendent.

## SHIPBUILDING IN MONTREAL.

In the May issue of this journal we published an illustrated article showing what was being done in the way of shipbuilding at Canadian Vickers plant. We are now informed that the boat shown on No. 2 berth (page 175) was launched on June 8th, that on No. 1 berth (page 177 was launched on June 29th, and that the one on No. 4 berth (page 171) will be launched on July 22nd, and another will follow on August 12th. At the time our article was written another ship was lying in the water which has since been completed and handed over to Messrs. Furness Withey & Co., for service. By the end of July, one half the schedule as outlined by the officers of Canadian Vickers will have been completed and delivered.

## HAMILTON NOTES.

The Dominion Steel Foundry Co., Ltd., have commenced work on a fine new Service Building. It is to be of reinforced concrete and brick, four stories high with good basement.

The store room will be housed here for plant stores as well as the pattern shop, pattern storage, etc. The Canadian Engineering and Contracting Co., Ltd., have the contract for the building. A. Cope and Son are sub-contractors for the excavation for the basement.

The Hamilton Bridge Works Co., Ltd., are erecting a good sized addition to their buildings at their East End works. The Canadian Engineering and Contracting Co., Ltd., have the contract for sewers and foundations.

The Steel Co. of Canada, Ltd., are erecting a very handsome 175 ft. brick chimney in connection with the new coke ovens at their Hamilton works. This firm reports all departments working to full capacity.

The Canadian Westinghouse Co., Ltd., have moved into their new office building which has just been completed. We gave an account of this building in our May issue. It is unquestionably the finest office building for a manufacturing concern in this city, if not in the Dominion. It is to be expected other firms will soon follow their example and put up good buildings for their offices.

A serious fire occurred at the Canada Iron Foundries, Ltd., Stuart St., on the afternoon of June 19th. The fire started in the fan house and a good deal of machinery and electrical equipment was destroyed.

The loss is estimated at from $12,000 to $15,000 on building and contents. It will mean that certain departments of the plant will be closed for about two weeks time.

It is gratifying to learn from the Frost Steel and Wire Co., that the condition of the steel market for wire fence purposes, etc., is reasonably satisfactory. The United States Government have placed this product in practically the same class as agricultural implements and no serious difficulty is being found in obtaining the raw material required for this class of work.

The Hamilton Bridge Works Co., Ltd., have recently shipped several large plate girder spans to New Brunswick for the I. C. Ry.

They are also erecting a five span bridge at Shaw Creek, Muskoka, for the C. P. R., but bridge work just now is pretty quiet; these, with the exception of one or two small bridges, being the only work of this kind that has passed through the shops for some months.

The annual meeting of the Hamilton Branch of the Canadian Manufacturers' Association, was held at the end of May. Mr. H. H. Champ, Secretary-treasurer of the Steel Company of Canada, was elected chairman for the coming year. (A report is published elsewhere in this issue.)

Mr. Geo. H. Madgett is leaving the Hamilton Bridge Works Co., Ltd., to take up work with the Standard Steel Construction Co., of Welland.

Mr. Madgett has been in the drawing office of the Bridge Works about twelve years and now will take charge of the drawing office at Welland as well as probably a good deal of the estimating and design work. Mr. Madgett's new duties commence July 1st. His many Hamilton friends wish him every success in his new position.

The Standard Steel Construction Co. is a fine little concern with plenty of enterprise and good backing, and in these days of difficulty for structural shops they are getting their share of work. Mr. Clark Madgett, a brother of the gentleman mentioned above, is sales engineer for this concern, with headquarters in Hamilton.

## NEW INDUSTRY TO BE LOCATED IN THIS CITY.

### Building and Equipment Call of Investment of $50,000. —Canadian Hart Wheels Company Also Expanding Its Plant.

C. W. Kirkpatrick, commissioner of Industries, announces that negotiations have been concluded for the establishment of a new industry, which will be known as the Hamilton Brass Manufacturing Company.

The new concern has decided to take over the charter of the old Hamilton Brass Company, and Hamilton men who will be large shareholders include W. H. Yeates, Max Yeates, Ernest Yeates and Murray Woodbridge.

The new company will at once erect and equip a modern factory on West Main street, on a part of the Frid brickyard property. The new building and equipment will represent an investment of $50,000. The old company for some time operated in a part of the old Baynes carriage factory, and these premises will be vacated at once.

The Hamilton Brass Manufacturing Company will carry on a business of which there is none other of the kind in Canada. Reclaiming of brass by manufacturing brass ingots from scrap brass will be the chief purpose of the new concern. Building operations will be commenced at once.

The fact that the Brass Company is giving up its quarters in the Baynes Carriage Company building has opened the way for expansion by the Canadian Hart Wheels Company. This concern is taking over the old Baynes carriage plant, and will vacate its present premises on East Barton street, near Wentworth street. Crowded conditions there make it impossible to have additions erected, and more room is required.

## NEW INDUSTRY.

### Commissioner Has Line on Another American Firm.

Another big American industry is interested in Hamilton, C. W. Kirkpatrick, commissioner of industries, recently being communicated with by an important specialty company across the line. This company manufacturers cloth and metal specialties, i.e., baby swings, rock-a-bye chairs, automobile baby seats, etc., and is considering locating here or making arrangements with some local manufacturer to turn out these products. Quotations on steel and wire were sought in the communication.

When annealing carbon steel stock for reamers, etc., heat the stock to a dull red and give it a blow or two on end. This will help to relieve the rolling stresses which tend to twist and bend the finished work when being hardened. If drawn on a hot plate or sand, lay on a cold block when the color is reached and allow it to cool. This will make the tool tougher than if quenched.

## ENGINEERS MEET.

### Branch of Institute Will Be Established in Hamilton.

Hamilton's place as an engineering and industrial centre was strikingly emphasized recently at a meeting at the Royal Connaught hotel, when over forty engineers assembled for the purpose of establishing a branch of the Engineering Institute of Canada in this city. The institute comprises the professional body of Canadian engineers, and, although there are many members of the parent institute in the city, no local branch has heretofore existed. At the meeting, which was followed by a dinner, J. L. Weller, M.E.I.C., of St. Catharines, presided. Mr. Weller's name is well known and will go down in engineering history as the man who designed and superintended the construction of the Welland canal, the magnitude of which is not appreciated by Canadians. The city engineering department was well represented, as well as the Canadian Westinghouse, the Steel Company of Canada, the Hamilton Bridge Company, the Otis-Fenson Elevator Company, the National Steel Car Company, Standard Underground Cable Co., the Wilputte Coke Oven Company, and others. Members were also present from St. Catharines and Niagara Falls.

Fraser S. Keith, of Montreal, secretary of the Engineering Institute of Canada, was present, and explained the necessary procedure in forming a branch, giving information regarding the renewed activities of the engineering profession and other matters of general interest. He referred to the fact that Hamilton was a most important industrial centre and promised a wonderful future for engineering activity. It was, moreover, one of the best situated cities on the continent, and could be counted on to take its place with the best in the industrial expansion that would follow the cessation of the war. Considerable enthusiasm was aroused in the discussion following, in which most of the men present participated.

City Engineer Gray pointed out the need for organization by engineers, it being essential that the men of the profession should be willing to take an active part, as public spirited citizens in matters of general interest.

R. K. Palmer, of the Hamilton Bridge Company, made a suggestion which was endorsed by all present that the engineers should be willing to co-operate with the board of trade and other public bodies, in assisting to advance the material interests of the community.

A resolution was passed and an application signed, to be presented to the parent institute at Montreal, asking for permission to establish a branch in this city. Pending the granting of this request, E. R. Gray, was appointed chairman, and E. H. Darling, secretary.

At the dinner following, a few brief speeches were made, in which reference was made to the engineer's place in the development of industry and the material welfare of the municipality. When established the Hamilton branch of the Engineering Institute of Canada will wield considerable influence. Those present included: E. R. Gray, R. K. Palmer, E. S. Jeffries, Corbett F. Whitton, A. E. Heffelfinger, William W. Perrie, A. E. Kerr, F. Werner, A. J. Gray, Walter Jackson, H. A. Ricker, A. C. D. Blanchard, Norman R. Gibson, J. L. Weller, W. D. Black, E. H. Darling, John H. Jackson, James J. MacKay, James Stoddart, M. A. Kemp, J. B. Nicholson, Charles D. Campbell, A. S. B. Lucas, C. E. Brown, J. A. Knight, C. W. Baker, A. Failey, A. H. Murray, M. J. Henderson, A. S. Crooks, E. Strasburger, H. W. Blorham, H. B. Dwight, G. A. Price, P. Ford Smith, S. W. Brown, W. B. Hood, H. E. Janney.

---

## JOHN H. KERR DEAD.

### Secretary of Westinghouse Co. Passed Away on June 24th.

John H. Kerr, a native of Pittsburg, and associated for many years with the enterprises of the Westinghouse Company in America, Canada and Europe, died after a short illness on June 24, at his home, 109 Aberdeen Avenue.

Mr. Kerr began his career with the Westinghouse Electric and Manufacturing Company in Pittsburgh, which was his home city, in 1892, and remained with the firm until 1901. During this period he was called to Europe to assist in the organization of the English Linotype Company and the French Westinghouse Company. In 1901, upon the formation of the British Westinghouse Company, Mr. Kerr went to Manchester to inaugurate factory systems for that company. When the Canadian Westinghouse Company, Limited, was organized, in 1903, Mr. Kerr was elected secretary of the company, and has filled that office and resided in this city for the last fifteen years.

Mr. Kerr was an esteemed member of St. Paul Presbyterian church, a member of the Hamilton club and a past president of the Hamilton Automobile Club. He is survived by his widow.

The funeral service was held at his late residence, 109 Aberdeen Avenue, and interment was at Pittsburg, where he was born.

---

## SHELL OUTPUT.

### Hamilton Expected to Get Big Share of Orders.

Announcement that the Imperial Munitions Board has been asked by the British Ministry to provide an increased supply of 18-pounder shrapnel shells from Canada, is of interest to local manufacturers, Hamilton establishments being particularly well equipped to meet these new demands. It is desired that the present supply be increased to 220,000 shells per week. A year ago 375,000 shells per week were being turned out in Canada. Then the output was reduced to 120,000 shells per week. The Munitions Board has communicated with various manufacturers of this type of shell, and have placed before them the urgent requirements of the British authorities. Hamilton is expected to largely share in the increased output.

---

One of the most convenient things for a carbon tool hardener to have near his forge or furnace is a small pocket compass. This should be set on a wooden box or stool in such a position that the heated tool may be swung over it from time to time as the heat progresses. When the tool ceases to move the needle the time to quench it has been reached. In using a compass for this purpose, however, it must be remembered that iron hooks or tongs will cause the needle to deflect, and it is well to transfer the tool to a brass hook as soon as it is taken from the fire.

---

When drawing, die, or other tool to color, a little lard oil rubbed on the surface will keep it from smoking up and will give a clear view of the colors as they appear.

# Carbocoal

By CHARLES T. MALCOLMSON,* Chicago, Ill.
Member of American Institute of Mining Engineers.

An elaborate series of experiments has been conducted during the past 3 years at Irvington, N.J., which has resulted in the perfection of a process for the manufacture of smokeless fuel from high-volatile coals, and for the recovery and refinement of the coal-tar products derived therefrom. These experiments have been financed by Messrs. Blair & Co., of New York, and were conducted under the direction of Charles H. Smith, a member of this Institute, and the inventor of the process.

The low-temperature distillation of coal has interested investigators for many years. Sporadic attempts have been made to solve the mechanical problems, but until the Smith process was developed, they were not carried to conclusions of economic value. The present coal shortage and the increasing demand for smokeless fuels make this subject one of timely interest.

### Description of Plant.

The following equipment was installed and operated during the experimental period: Four horizontal and two vertical units of commercial size for the low-temperature distillation of the coal; two vertical, two horizontal, and two inclined benches for distillation of the briquets at medium and higher temperatures; presses and auxiliary equipment necessary for making briquets; and a complete by-product recovery and tar-refining plant. This commercial equipment is provided with gas and electric meters, pyrometers and other apparatus for recording accurately the results of all experiments.

There is, in addition to the commercial equipment, a complete chemical laboratory with distillation and recovery apparatus, including facilities for refining and cracking the tar and measuring the yields and calorific value of the gas. This apparatus makes possible a study on a small scale, of the various problems involved in the process.

### Description of Process.

Mr. Smith's experiments have resulted in the production on a commercial scale of:

1. A fuel, called Carbocoal, which, for convenience in handling, is prepared in briquet form.

2. A yield of tar more than double that obtained in the ordinary by-product coking process.

3. Ammonium sulphate in excess of that normally recovered in the ordinary by-product coking process.

4. Gas, in amount approximatell 9,000 cu. ft. per ton of coal carbonized, which is at present used in the process.

The essential features of the Smith process are the two distillations carried on at different temperatures, first of the raw coal and second of the raw briquets. The raw coal, after being crushed, is distilled at a relatively low temperature, 850 deg to 900 deg. F., and the volatile contents are thereby reduced to the desired point. The result of this first distillation is a large yield of gas and tar, and a product rich in carbon, termed semi-carbocoal. The semi-carbocoal is next mixed with a certain proportion of pitch obtained from the tar produced in the process, and this mixture is briquetted. The briquets are then subjected to an additional distillation at a higher temperature, approximately 1800 deg. F., resulting in the production of carbocoal, the recovery of additional tar and gas, and a substantial yield of ammonium sulphate.

The characteristic feature of the primary distillation is that it is continuous and that the coal is constantly agitated and mixed during the entire operation. This is accomplished by a twin set of paddles which also advance the charge through the retort. By this means, all portions of the charge are uniformly distilled, and by controlling the speed at which the charge moves through the retort, the distillation may be arrested at any desired stage. As only a partial carbonization is permitted in the primary distillation, the hard metallic cells characteristic of coke are avoided. The period of distillation is 1 to 2 hours, and the continuous retort has a carbonizing capacity of one ton of coal per hour.

In the subsequent distillation of the briquets, all evidence of the pitch as a separate ingredient disappears. There is a marked shrinkage in the volume of the briquet, with a corresponding increase in density, but no distortion of its shape. This distillation requires 4 to 5 hours, and is performed in an inclined, self-charging and self-discharging bench.

The carbocoal represents more than 72 per cent of the weight of the raw coal, the exact percentage depending upon the volatile content of the latter.

### Carbocoal.

Carbocoal is dense, dustless, clean, uniform in size and quality, and can be readily handled and transported long distances without disintegration. It is grayish black in color, slightly resembling coke, but its density more nearly approaches that of anthracite coal. It is manufactured in briquet form and can be made in any size, from 1½ oz. to 5 oz. The larger sizes are better suited to locomotive purposes, and the smaller sizes for domestic use.

Heretofore, devolatilized fuels, such as coke, have not attained the high rates of combustion desired for locomotive, marine and general steam purposes; and their greater displacement has operated against their general use where transportation cost of stowage space has been an important factor. Carbocoal overcomes these objections. It is actually a relatively soft but tough form of carbon, readily attacked by oxygen in combustion; and for this reason, requies much less draft than other high-carbon fuel.

### Carbocoal for Steam Purposes.

Carbocoal has been tested by the Long Island Railroad; by the Pennsylvania Railroad at its testing plant at Altoona; by the Carolina, Clinchfield & Ohio Railroad; and by the United States Navy.

These tests have demonstrated that the fuel is smokeless; that it will evaporate from 8.5 lb. of water at a combustion rate of 100 lb. per square foot of grate surface per hour, to 12.8 lb. of water at a combustion

* President, Malcolmson Briquette Engineering Co.

rate of 27 lb. per square foot of grate surface per hour, from and at 212 deg. F., per pound of fuel fired; and that it requires no greater draft than bituminous coal. A maximum combustion rate of 166 lb. per square foot of grate surface per hour has been reached for a short period.

Carbocoal has been found particularly suitable for the following purposes:

1. Marine and locomotive service, where limited grate area and restricted boiler capacity demand efficient fuel; where smoke is objectionable or dangerous, as in the case of ships in time of war.
2. Stationary boilers, where smoke pollution of the air is offensive and dangerous to health.
3. Domestic uses, including furnaces, stoves, ranges and open grates, where cleanliness is a desirable factor.
4. Kilns, drying and roasting ovens, and all purposes where an intense and uniform heat is desired.
5. In metallurgical furnaces, as a substitute for coke.
6. Gas producers.

### Carbocoal as a Domestic Fuel.

Carbocoal has been subjected to practical tests in household use for over one year. It fulfils all requirements of a domestic fuel. It can be burned satisfactorily without change of furnace or grates, responding readily to changes in draft. The uniformity of combustion, absence of fines, even distribution of ash, and absence of clinker as compared with the coal from which it is made, are additional characteristics in favor of this fuel.

Tests have demonstrated that carbocoal can be banked satisfactorily over night, requiring no more attention, and with no greater consumption, than anthracite.

### Comparison with Other Briquets.

Carbocoal is compressed into briquet form to obtain maximum density, to minimize transportation costs and the losses incident to handling; and to secure the efficiency of combustion resulting from uniformity of size.

Briquets of bituminous and anthracite coals have been manufactured for many years. Such briquets are made from the smaller sizes or screenings of coal, with the addition of a binder, such as coal-tar pitch. In carbocoal, however, an entirely new product is obtained, differing from the original coal in chemical and physical properties. The briquets contain no binding material to soften or disintegrate in the fire. Carbocoal, must therefore be recognized not as a mixture, but as a new product, the result of a process of manufacture.

### Analysis of Carbocoal.

The amount of ash and sulphur in the carbocoal depends upon the characteristics of the coal from which it is made. The summarized proximate analyses of carbocoal, manufactured from 25 different coals at the Irvington plant, are shown in Table 1.

TABLE 1.—Analyses of Carbocoal.

| | From Run of Mine, P.c. | From Washed Coal P.c. |
|---|---|---|
| Moisture | 1.00 to 3.00 | 1.00 to 3.00 |
| Volatile matter | 0.75 to 3.50 | 0.75 to 3.50 |
| Fixed carbon | 82.00 to 88.00 | 85.00 to 90.00 |
| Ash | 8.50 to 12.00 | 7.00 to 10.00 |
| Sulphur | 0.5 to 1.50 | 0.6 to 1.50 |

The percentage of by-products recovered from clean coal is greater than that recovered from high-ash coals; therefore the careful preparation of the raw coal by washing or other means is profitable.

### Tar and Its Products.

The total yield of tar by the carbocoal process is large. Coal containing 35 per cent volatile combustible produces more than 30 gal. of water-free tar per short ton.

The tar obtained in the primary distillation of the the coal, at the low temperature used in this process, are different in nature from those obtained in other processes where high temperatures are used. At the lower temperature, there is an abundance of tar vapors, and a relatively small yield of gas of high illuminating value. At the higher temperature these primary products are split up, with a consequent increase in the gas yield and a corresponding decrease in its illuminating value and in the amount of tar vapors recovered. There is also an increase in the percentage of residuals, the pitch increasing from 30 per cent in the low-temperature distillation, to 64 per cent or more when high temperatures are used.

The tar obtained in the primary distillation of the coal has a specific gravity of 1.00 to 1.06. It contains a large percentage of light solvent oils, tar acids, and cresols, but very little carbolic acid and no naphthalene or anthracene. The free-carbon content of this tar is low. The light oils contains appreciable quantities of naphthenes, pentane, hexane, hexahydobenzenes, and also hydrocarbons of the paraffine series, which make these oils valuable as a substitute for gasoline.

A satisfactory method of removing the paraffin and aromatic portions of the light oil has been developed, so that c.p. benzol and toluol can now be obtained by this process. During the low-temperature distillation period, 20 to 28 gal. of tar, including the light oil obtained from the stripping of the gas, are recovered, the exact amount depending upon the volatile content of the coal. This low-temperature tar contains approximately 30 per cent of pitch and 70 per cent of tar oils, as compared with 50 to 60 per cent of pitch and 40 to 50 per cent of oil products contained in ordinary gas-house and coke-oven tar.

In the second or high-temperature distillation, 5 to 6 gal. of tar are added to the above yield. This tar is heavier than that obtained from the first distillation, and is similar to coke oven tar.

Table 2 compares the tars and light oils obtained in the production of carbocoal with those obtained in the ordinary by-product coking processes.

TABLE 2.—Recovery of Liquid Products per Ton of Raw Coal.

| | Distillation. Temperature Deg. F | Byproduct. Coke Oven. Gal. | Byproduct. Coke Oven. P.c. | Carbocoal,1st Distillation. Gal. | Carbocoal,1st Distillation. P.c. | Carbocoal,2nd Distillation. Gal | Carbocoal,2nd Distillation. P.c. |
|---|---|---|---|---|---|---|---|
| Light oil | 0-170 | 0.27 | 3.47 | 1.58 | 6.60 | 0.003 | 0.05 |
| Middle oil | 170-230 | 0.44 | 5.85 | 3.29 | 13.70 | 0.036 | 0.60 |
| Creosote oil | 230-270 | 0.78 | 10.37 | 3.11 | 12.95 | 0.126 | 2.10 |
| Heavy oil | 270-360 | 1.26 | 16.81 | 8.88 | 37.00 | 2.485 | 41.42 |
| Pitch | ..... | 4.66 | 62.18 | 6.90 | 28.75 | 3.290 | 54.83 |
| Loss | ..... | 0.09 | 1.32 | 0.24 | 1.00 | 0.060 | 1.00 |
| Totals | ..... | 7.50 | 100.00 | 24.00 | 100.00 | 6.000 | 100.00 |

In adition to the above yield of tar there is obtained, in both the by-product coke oven and the carbocoal process, by stripping the gas, from 2 to 3 gal. of light oil. This yield depends upon the characteristics of the coal carbonized.

Approximately 30 per cent of the fractions from 170 deg. to 360 deg. F. in the carbocoal process are tar acids; the remainder of the fractions are neutral oils.

The value of the products from the distillation of tar

depends, of course, on the extent to which the tar is refined. The fractionation and subsequent treatment of the tar oils, which is a part of this process, give the products shown in Table 3, in carbonizing 1000 tons of coal; the figures are based upon data obtained from carbonizing run-of-mine coal from Clinchfield, Va.

1. Carbocoal . . . . . . . . . . . . . . . . . . . . . . . . . . .725 tons.

| | Analysis. Raw Coal. | Carbocoal. |
|---|---|---|
| Moisture . . . . . . . . . . . | 0.72 | 1.84 |
| Volatile matter . . . . . . . | 35.01 | 2.75 |
| Fixed carbon . . . . . . . . | 57.23 | 85.64 |
| Ash . . . . . . . . . . . . . . . . | 7.04 | 9.77 |
| | 100.00 | 100.00 |
| Sulphur. . . . . . . . . . . . . | 0.63 | 0.52 |

2. Sulphate of ammonia . . . . . . . .20,000 to 25,000 lb.
3. Other nitrogen products, principally, pyridine bases, approximately . . 2,000 to 4,000 oz.
4. Motor spirits . . . . . . . . . . . . . . . . .1,800 to 2,200 gal. (or c.p. benzol, 250 gal., c.p. toluol, 500 gal., motor spirits, 1000 gal.)
5. Crude tar acids principally cresylic acids . . . . . . . . . . . . . . . . . . . . . . . . . . . .4,040 gal.
6. Water-white naphthas . . . . . . . . . . . . . . .3,500 gal.
7. Creosote oil . . . . . . . . . . . . . . . . . . . . . . . . . .5,450 gal.
8. Heavy creosote oil . . . . . . . . . . . . . . . . . . .4,660 gal.

Other products, used in process:

9. Pitch . . . . . . . . . . . . . . . . . . . . . . . . . . . . .10,000 gal.
10. Gas, of 530 B.t.u., approximately . . 9,000,000 cu. ft.

Pitch is always an element of questionable value in tar distillation. The Smith process, however, utilizes all of its pitch for briquetting the semi-carbocoal produced by the first distillation. Moreover, the valuable portions of this pitch are recovered in the tar and gas resulting from the second distillation. It is therefore noteworthy that all the tar products recovered by this process are oil derivatives.

### Ammonium Sulphate.

The primary distillation of the raw coal gives only a small yield of ammonium sulphate. The secondary distillation of the raw briquets, however, brings the amount up to approximately 21 lb. per short ton of raw coal carbonized.

### Gas.

In the primary distillation of the raw coal, from 5000 to 6000 cu. ft. of gas per short ton of coal is recovered. This has a heating value of 650 to 700 B.t.u. per cubic foot. The distillation of the briquets yields also about 4000 cu. ft. of gas of 350 to 400 B.t.u. per cubic foot. The process in its present stage of development uses all of the gas recovered from both distillations.

This paper will be read at the Colorado meeting in September, 1918.

---

If a drop of nitric acid be put on polished wrought iron and steel, the steel will turn black. The higher the carbon the blacker the spot.

---

When trying out a new brand of steel, it is better to do as the maker recommends, as one method will not fit all kinds, even if it has proved satisfactory on two or three.

## MEETING OF CANADIAN MANUFACTURERS' ASSOCIATION.

### H. H. Champ Presides Over Hamilton Branch.

The rival merits of protection and free trade are once more to be paraded before the Canadian public, if an address delivered by S. R. Parsons, president of the Canadian Manufacturers' Association, before the Hamilton branch of the C. M. A., in the Board of Trade rooms May 30th, on the occasion of its annual meeting, is any criterion. Mr. Parsons intimated that, goaded by the free trade talk in the west and among the politicians at Ottawa, the manufacturers would make a big stand on the protection issue at their annual convention in Montreal within a few weeks' time.

"The time has come for the manufacturers to show their colors," Mr. Parsons declared. "We were told during the election, by Hon. T. A. Crerar, that the tariff would not be a live issue during the time of war. But now the west is full of free trade talk. You hear it from the press, the politicians and the platform. They are asking that the protective tariff on agricultural implements be lifted as a starter. It is up to the Canadian Manufacturers' Association to show the government, show the politicians, show the public, that the manufacturers must be protected in the interests of the country."

The whole matter will be thrashed out at the annual convention of the C. M. A., at Montreal, when it is expected that the industrial captains will come out flat-footed in defence of the tariff.

H. H. Champ, who during the meeting was elected chairman for the ensuing year, presided.

### Annual Report.

The annual report of the chairman, W. H. Marsh, of the Standard Underground Cable Company, was presented by the acting chairman, H. H. Champ, in the absence, through illness, of Mr. Marsh.

The report follows:

It is impossible for one to be connected in any official capacity with the Canadian Manufacturers' Association in the carrying out of its great work in the interest of the manufacturers of the country without becoming imbued with the deepest interest in the work being accomplished by the association through its council, committees, head office departments, and its several branches, including Hamilton branch, of which I have the honor to be chairman.

It is therefore a matter of very deep regret to me that I am unable to be with you at this, the annual meeting of our branch, to personally deliver my report on the activities of the branch during the past year.

### Transportation Car Demurrage.

The Director-General of Railroads of the United States, having absolute authority, has issued a set of demurrage rules effective Feb. 10, throughout the United States, as follows:—

For each of first four days after free time, $3; for the next following three days, $6, and for each succeeding day, $10.

For purposes of comparison, our present Canadian demurrage charges are shown as under:

One day after free time, $1; two days after free time, $2; three days after free time, $3; four days after free time, $4; five days after free time, $5 and $5 thereafter.

As we may be called upon to fall in with the new American demurrage rules by way of co-operation with

United States Director-General of Railroads, in the great problem of car supply, it would be well that this matter receive careful consideration, so as to be prepared to meet such an eventuality.

Under complaint of shippers, made through the Canadian Manufacturers' Association, in regard to the operation of demurrage rule 2A, having to do with delivery of advice notes on Saturdays covering carload shipments, this matter was heard by the Railway Board at Ottawa, May 21. The finding of the Board was that notification of arrival, mailed on Friday night and delivered Saturday, did not give time to take care of customs clearances, and while there was no delay to customs' entry, it was granted on such advice notification, as stated. Monday would be considered free time for clearance. This is a very important amendment to the public generally, as undoubtedly the shortened banking hours of a Saturday, now 12 noon, after which hour it is impossible to have duty checks marked for entries, has caused heavy demurrage charges to accrue against owners of freight.

A number of new regulations have been established adding to difficulties of transportation, notable among which are the import and export license regulations. In the United States war trade board export licenses are necessary for all shipments from Canada making exit from all United States ports to all foreign countries. It is not necessary that these licenses accompany the shipment, but when secured must be filed with the United States collector of customs at the seaboard. Export license is also necessary covering a long list of raw materials, which each manufacturer must familiarize himself with.

The United States also require an import license on all shipments forwarded from Canada into that country, and on these the license must be produced where valuation exceeds $100, and the United States consuls have been instructed not to issue consular invoices unless these papers are produced. However, the modification to take care of shipments of less than $100 in value is that the handling broker at the border can arrange for issue of these licenses on examination of goods, these forming part of the regular clearance.

These regulations, effective on both sides of the line, have created considerable confusion, but this was no doubt due to inexperience common with license boards and the shipping public, but this is rapidly righting itself.

Our government has appointed a war trade board at Ottawa to facilitate the securing of export licenses for shipments of commodities of Canadian origin to the United States, or export.

### Pooling of Equipment.

While pooling of equipment has not been recognized by Canadian railroads, they have been very liberal in this regard, owing to the fact that a great deal of their own equipment is on the other side of the line. Pooling, as you no doubt understand, refers to the privilege of using equipment irrespective of home route. This has tended toward increased movement of traffic, and we believe the effort has been along the right line, because during the present month all roads, at least in this district, are in a position to offer shippers all sorts of box-car equipments, but for some unaccountable reason, the same cannot be said in regard to flat cars, which are very scarce. It is very strongly urged upon the members not to delay taking advantage of the relieved traffic situation, as it may possibly be only of a temporary nature. During the past winter months congestion of traffic was most acute, especially at frontier points. The situation became so grave that it was found necessary to adopt some drastic measures, and by direction of Sir Henry Drayton, F. F. Backus, a member of the Canadian railway war board, was appointed general supervisor or traffic distributor at the Buffalo and Niagara frontiers, and between January 4 and March 4, about 5,000 cars were diverted, irrespective of the billed route, to the line best able to handle them, and by reason of this saved Canada a very grave shortage of coal. Buffalo wanted to confiscate the coal, but through the efforts of Mr. Backus with the war board at Washington, he was successful in bringing it into Canada.

### Proposed Classification No. 17.

There are no new developments to report in connection with proposed classification No. 17, the matter in the meantime being held in abeyance.

### Rate Increase 15 Per Cent.

The rate increase of 15 per cent to western points became effective on April 1. While the class rates were in reasonable accordance with the order of the board, in some instances objection will be filed to increases on commodity carload minimums, which have been increased unduly without due notification. The general 15 per cent increase on eastern territories became effective on March 15.

### Coal Situation.

Our head office sent out a circular to all members, urging that they arrange to take care of next season's coal supply during the early summer months, and it is a fact that all the large consumers are acting upon this advice. The United States coal commission thoroughly appreciates this effort, and has treated Canada liberally by license permit.

### Amendment to the Consolidation of the Railway Act.

The item of interest in this amendment is that which has been called to the attention of the members for the last two years, that of placing all water-carriers on the great lakes under regulation of the railway commission. Whenever this matter came before the committee of the house it has been strongly opposed and this feature of the act defeated, but the proposer, with decided persistency introduces the same question each year. It was sprung suddenly during the session just closed in an effort to put it through, but the opposition, filed by telegram by various interested members of our association throughout the territory affected, had sufficient influence to have the bill laid over indefinitely, and with the further assurance that due notification would be sent all concerned before coming up again.

### Technical Education.

Hamilton branch is vitally interested in the proper development of technical education in the city of Hamilton, and has donated liberal prizes for the encouragement of the students of the Technical school. During the last two years the Technical school has made wonderful progress, both in the enrolment of pupils in day and evening classes and in the character of the training afforded in its shops and classrooms. The last report of the principal to the technical committee shows that over 1,200 pupils received instruction in this institution during the year 1917-1918.

Employers of the city are beginning to realize that the Technical school is a part of the industrial life of the city. Apprentices from over 20 firms attend

the school one half-day each week for instruction in subjects related to their trade. In fact, the development of part-time apprentice training in the Technical school is the most encouraging work of the kind on the continent.

Early in 1917 the technical committee of the board of education recommended that steps be taken to erect new Technical school buildings on the six-acre site purchased a few years ago for this purpose. Unfortunately, some members of the board of education at that time counselled delay, on the ground of increased cost of construction. Later on in 1917 a delegation from this association and the Board of Trade waited upon the Board of Education and urged the construction of a new technical school, but for some reason or other no attention was paid to our representations.

The time has come for action in this matter. The war has made serious demands upon skilled labor in this country. Means must be taken speedily to replenish the supply of skilled workers, otherwise our industrial growth will be checked beyond repair. The technical school is the training place for the skilled workers of the future. Its usefulness should not be impaired by lack of room, equipment or staff required to train the hundreds of boys who must be developed in skill of hand and brain to take the places of the workers who are fighting for the empire overseas.

At this time when other nations are awakening to the necessity for increasing facilities for technical education so that they will be prepared for industrial competition which is sure to follow the conclusion of hostilities, it is folly to put off the construction of buildings which are needed for this purpose in Hamilton.

The Ontario government has been very liberal in its grants for the furtherance of technical education in this city. The entire cost of equipment and half the cost of teachers' salaries is paid for by the government. Because of this aid technical education is costing the taxpayers less than any other form of public instruction, and there is no reason why the community should not supply suitable and adequate accommodation for carrying on successfully the work now so well begun. There should be, I believe, no further delay in building the new technical school.

### Returned Soldiers.

Members of our association have been actively identified with all of the more important patriotic efforts arising out of the war, but would like to make special mention of the soldiers' aid commission, through which returned soldiers are being absorbed into civil life. Instructions have been issued at all of our factories that returned soldiers, where at all possible, are to be given the preference in the filling of vacancies, and from figures obtained from the commission it is shown that during the month of April out of 90 applications for men, 5 were placed, and a partial report for the month of May shows that of 59 applications, 54 men were placed. The balance of the positions could have been filled, but the men declined the work offered. It is pleasing to report that over 95 per cent of the positions thus filled with returned men were in industrial establishments.

### Farm Help.

In August last an appeal was made by the provincial premier to the manufacturers and large employers of labor for assistance in securing temporary help on the farms, to help to harvest Ontario's crops. Hamilton's quota was set by the Food Controller at 500 men, and special meetings of our association were held to consider this vital question. Through Mr. Wills, superintendent of the Ontario employment bureau, it was learned, however, that 100 men were all that would be required from Hamilton, and it was felt that there must have been some misunderstanding between the food controller and the organization of resources committee.

The response of the employers of Hamilton is something to be proud of, and as an indication of the splendid spirit of co-operation with the premier in his request, I might state that from only five of our members canvassed, a total of 254 men were offered as volunteers for this important work. What the total number of volunteers would have been had it been necessary to continue the canvass can only be surmised, but it is clearly evident that the original quota of 500 would easily have been exceeded.

### Electric Power.

The electric power situation has been very serious for the past several months, and while it is a little easier at the present time, the improvement is nothing like adequate to meet the requirements. From the latest information obtainable, it would appear that there may be an additional allotment of power added about October or November, but this could not be guaranteed. Unless something is done toward an incerase of electric power, it may be necessary during the next winter months to curtail the power to non-essential users, but it is earnestly hoped that this will not be necessary.

### Natural Gas.

The order by the Ontario railway and municipal board, restricting the use of natural gas for domestic purposes only, after the first of July, has been receiving our attention, and at a joint meeting of manufacturers of Hamilton and other nearby municipalities affected, a strong resolution was prepared for presentation to the minister of mines and railway board, in which it was pointed out that the equipment required for the installing of other substitutes for natural gas had to be imported from the United States, and in many instances could not be procured and installed by the first of July, and would mean actual closing down of some of our industries for a considerable length of time, and an extension of time was asked where necessary; also it was asked that a certain reasonable allotment of gas be allowed where essentially required in processes in manufacturing plants.

The matter is still under consideration, and we feel will likely be disposed of within ten days' or two weeks' time.

Other large matters engaging our attention are Canada's Post War Problems, Industrial Research, and Foreign Trade, any of which is important enough to be the subject of a whole evening's discussion.

In closing, I would like to thank the members for having honored me with the second term in office, and to express to the officers and committees, and the general membership, my deep appreciation for the assistance that has been rendered me as chairman of the branch during the past two years.

### Secretary-Treasurer's Report.

The report of the secretary-treasurer, H. E. Waterman, was read. Nine new members were added to the association during the year. Four companies resigned; the total membership is now 213. A strong effort will be made to add to the membership of the association during the ensuing year.

A very favorable financial report was presented by Mr. Waterman. It was noted that $1,500 was invested in 1917 war loans.

A vote of regret at the inability of Mr. Marsh to attend was passed, and Mr. Marsh was warmly praised for his work on behalf of the association and for his splendid report.

### New Chairman's Remarks.

H. H. Champ was unanimously elected chairman of the C. M. A., succeeding Mr. Marsh. In referring to the problems confronted by the association during the year, Mr. Champ touched on the returned soldiers' employment. He said that he felt that there was not a manufacturer in Hamilton who did not desire to employ the returned men whenever possible.

Mr. Champ said in regard to the farm labor problem that he did not think it fair that manufacturers should be called upon to loan their employees to the farmers and pay the former the difference between the employee's regular wage and what the farmer would pay, stating that the farmer was at present receiving good prices for his produce. At the same time he urged every co-operation between the manufacturers and farmers, and said that in the event of a serious shortage the manufacturers should lend assistance in farm produce.

Mr. Champ mentioned that the annual convention took place in Montreal on June 12, and he thought that every member of the association should make it a point to attend, to demonstrate the interest which Hamilton took in the organization.

### S. R. Parsons.

S. R. Parsons, of the British-American Oil Company, Toronto, president of the Canadian Manufacturers' Association, was introduced by the new chairman.

In commencement, Mr. Parsons acknowledged that there was no more important manufacturing centre in Canada than Hamilton, and he praised the go-aheadness of its captains of industry. He also expressed his appreciation of the services of Mr. Champ on the executive committee.

### Buy Your Coal.

Referring to the coal situation, Mr. Parsons counselled manufacturers to secure their coal as soon as possible, in spite of seeming high prices. The fuel controller was also of the same opinion.

"The returned soldiers after the war will be crowded in the cities, looking for employment," said Mr. Parsons. "Much as we would like to see them placed on the land, we may be sure that all of them will not go out on farms. And, mark my words, the farmer will not take any responsibility. The returned soldier question is one which should engage the serious consideration of every manufacturer."

### Harvesting.

Regarding the harvesting situation, Mr. Parsons said that last year the crops would not have been harvested had it not been for the manufacturers' help. About 6,000 employees of factories went out and worked in the harvest field. He admitted that the wage question was one full of difficulties, although he agreed with Mr. Champ, that manufacturers should not be called upon to pay the difference in wages. Manufacturers last year did nobly, he said, and did not take into consideration the fact that they did more than their share, in order that crops might not be wasted.

### Interesting Employees.

Mr. Parsons proceeded:

"The time has come when we must be prepared to give some consideration in interesting our men more directly in the operations of the plants. Unless democracy is to prove but a label on the bottle, we have got to make a start to interest our employees in the factories in a way we have not done in the past. There has been a lot of beautiful idealism expressed in the press and the pulpit. We have arrived at a time when it is a question of either evolution—carrying our men along with us—or revolution, and we have seen the effects of the latter in revolution."

Mr. Parsons admitted that no fixed system could be applied to every manufactory, but the work could be started in an industrial way. "We have got to exemplify the spirit of democracy," said the speaker. "The internal conditions at present cannot give rise to satisfaction."

Mr. Parsons drew attention to what even the Standard Oil Company was doing along the lines of insuring all its regular employees, which he said showed what was in the minds of manufacturers on the other side of the border. Schemes were in preparation to make the men more attached to their places of employment.

"This is what is before us, and, as individuals, we will have to evolve some scheme. If we have the proper spirit of trying to do our best to all our employees, the way will be open as we attack the problem," said Mr. Parsons.

### No Lead From Government.

The speaker referred to the steps taken by England and Australia to foster and stimulate industry after the war.

"We haven't had the lead of the government as we should have had," declared Mr. Parsons.

"What are we going to do to meet the staggering debt which has accumulated? It is a pity we haven't more business men in the government and in parliament to legislate with the qualification of a business experience. The only thing that we can do is produce, in mines, forests, lands and factories.

"If we have courage, faith, and a readiness to stick to it, I believe that Canada, with her immense resources, her virile, God-fearing people, has no fear for the future of the nation," concluded Mr. Parsons, amidst applause.

A resolution, moved by H. H. Biggert, seconded by G. C. Coppley, was tendered to the speaker. In seconding the vote Mr. Coppley said that with the great tracts of land lying in the vicinity of the great markets it would be folly to send returned soldiers to pioneer in the wilds of northern Ontario. He regretted that the government had not given the manufacturers a lead in meeting big problems.

The election of officers and committees resulted as follows:

Officers—H. H. Champ, chairman; Geo. H. Douglas, vice-chairman; H. E. Waterman, secretary-treasurer.

Executive committee—Henry Bertram, J. A. McMahon, Cyrus A. Birge, A. F. Hatch, W. B. Champ, H. P. Hubbard, R. Hobson, Geo. C. Coppley, W. R. Dunn, H. L. Frost.

Ex-officio members—H. H. Biggert, R. R. Moodie, H. J. Waddie, W. H. Marsh.

Finance—Geo. C. Coppley (chairman), N. Slater, W

E. Skelton, C. W. Sherman, K. Bethune, Cyrus A. Birge.

Membership—H. J. Waddie (chairman), W. M. Currie, G. W. Robinson, J. A. McMahon, W. E. Blandford, C. A. Murton, K. Bethune, G. E. Main, A. T. Enlow.

Municipal and legislation—G. H. Douglas (chairman), A. L. Page, J. W. Millard, D. B. Wood, Geo. A. Simpson, A. C. Garden.

Reception and entertainment—H. P. Hubbard (chairman), A. H. Tallman, G. E. Messer, H. G. Wright, P. M. Yeates, James Wagstaffe, F. M. Hatch, C. A. Murton.

Technical education—H. L. Frost (chairman), F. R. Close, H. J. Waddie, C. R. McCullough, R. C. Fearman, R. A. Robertson, P. Ford-Smith.

Transportation—W. R. Dunn (chairman), F. H. Whitton, W. R. Drynan, A. F. Hatch, C. A. Hunter, A. T. Enlow, Henry Bertram, F. W. Dean.

Executive council of the association—Geo. H. Douglas, A. F. Hatch, H. J. Waddie, Geo. C. Coppley, H. H. Biggert.

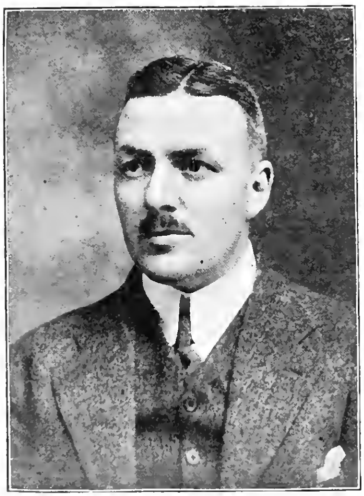
Legislation—H. J. Waddie, H. L. Frost, Geo. C. Coppley.

Insurance—J. W. Millard.

Transportation—W. R. Dunn, A. F. Hatch.

Tariff—H. H. Champ.

Membership and reception — H. P. Hubbard, K. Bethune, J. A. McMahon.



**MR. JOHN GRIEVE.**

**Sales Manager, Dominion Paint Works, Ltd.**

Mr. John Grieve, Manager of Sales for the Dominion Paint Works, Ltd., Walkerville, Ont., whose portrait is shown above, is well known to Canadian Iron and Steel men who appreciate the fact that a mill interior painted in brilliant light reflecting white is a first-class investment and not an expense. Like a good many other Canadians, Mr. Grieve hailed from Scotland, that rugged part of the British Isles which has done so much to put Britain on the map, and to keep it there. Edinburgh, the heart of Scotland; famous for a thousand years in picture, song and story, is his native city. Mr. Grieve received his early education in the renowned Herriot Watt College, an Edinburgh Institution that is one of the famous educational centres of that classic old city, and which has produced not a few men to whom Scotland and the world at large are deeply indebted.

After graduating from Herriot Watt College, Mr. Grieve was apprenticed for five years with the important Edinburgh engineering firm of Carrick & Ritchie. At the completion of his apprenticeship he severed his connection with that concern and accepted an appointment with George Russell and Co., Ltd., Motherwell, where the opportunity for advancement and an increased knowledge of his profession was greater. In this way he progressed upwards through the various departments of shop work and drafting offices. The experience gained at the bench and lathe enabled him to make rapid progress as a draftsman and designer.

From this position, Mr. Grieve was called to a more advanced post as chief draftsman with the Steel Company of Scotland, in which capacity he rendered efficient service for a considerable period. Ultimately, however, he resigned to become Resident Engineer with the Lanarkshire Steel Company, Ltd., in which capacity he was responsible for the installation of all new machinery, besides having to attend to other important duties.

In 1909 Mr. Grieve came to Canada and engaged with the Dominion Bridge Company in the designing and drafting department, but, at a later date he was transferred to the Montreal Contracting Office.

In 1914, the Dominion Paint Works, Limited, Walkerville, Ont., felt that their interests in the engineering and manufacturing industries, to which they were supplying large quantities of paint, would be most efficiently handled by an engineer, trained in the selling end, and conversant with the conditions governing the varied exposures of metallic structures. As a result Mr. Grieve was appointed Montreal representative, with jurisdiction over the East of Canada, and his technical experience has been of great value to iron and steel men who appreciate expert knowledge of metals, and the art of preserving same by means of the most approved type of pigments.

In 1916, Mr. Grieve was made Eastern representative and at the beginning of 1918 was advanced to Sales Manager for the company.

Mr. Grieve has his headquarters in Montreal, but the company likewise has sales offices in Toronto, Winnipeg, Vancouver and Sydney, in addition to the works and offices at Walkerville, Ont.

Mr. Grieve is an Associate Member of the Canadian Society of Civil Engineers. He also represents the paint industry in the Rotary Club of Montreal, the motto of which is—

"He profits most who serves best."

---

If a hardened, but undrawn, forming tool is laid in a draft after quenching the chances are that the tool maker will have to make another.

---

It is a poor plan to have the shop lettered up with a dozen different brands of unmarked steel—either mark each piece distinctly or stick to one brand.

# War Time and Inspection

It is nearly four years now since war broke out. Four years that have done more to change and develop conditions in the iron and steel industry than perhaps any similar period before known.

Those first few months will long be remembered, almost a panic ensued amongst manufacturers, men were laid off, salaries cut and times looked dark indeed. Then towards the close of 1914 war orders began to come in. Canada discovered she could do what other nations were doing and in a very short time we found ourselves manufacturing all sorts of articles never before "made in Canada." Indeed some of the things we began to make most of us had never seen before or possibly even heard of.

Immediately both the purchasers and manufacturers found themselves confronted by a most difficult problem.

In the metal industry alone almost every conceivable article was contracted for, from buttons and spurs to locomotives, gun-carriages, field kitchens and shells, —there were shells in every shape, form and stage of construction. And all these had to pass inspection. From the rough billet to the completed article there had to be inspection all the way through. There were rolled bars, unforged blanks, rough forgings, all to be inspected. Then there were rough turned shells and the completely machined article, there were cartridge cases and bullets, etc., etc., even down to the boxes they were packed in, and inspection for all.

A regular army of inspectors were required on the shortest notice, and the army appeared as it was required, everyone seemed to be inspecting something or other then, the most unlikely characters suddenly turned into inspectors, and practically none of them knew their business. Indeed, who was there in Canada who knew anything whatever about these articles of war? The manufacturers themselves, the men doing the work didn't know much more than the men inspecting it, even if they knew as much. How everyone worked! The experiments, the failures and the successes, only those who passed through it will appreciate, and then, when we thought all was lovely, came the inspection. How little some of those inspectors seemed to appreciate our noble efforts! How cruelly some of our work was turned down and how easily (occasionally) some of it passed.

But soon, however, things were in better shape. Allowable limits of error were more accurately determined, troubles were traced to their sources and aften eliminated. Heat treatment and microscopic examinations began to have a more important place in our thoughts and actions. Old rule of thumb methods had to be eliminated, the work was all so new, the men had to use their heads to get results.

The material was needed urgently. A terrible cry was going out for war supplies and everyone did his best to meet it. Everything that would do the job for which it was intended had to be put through, while no chances could be taken on poor material that would endanger the lives of our own men. The inspectors learned to judge in a more intelligent way as they better understood the product and the issues at stake.

The same idea spread from shell work and the like to other branches of industry. Steel structural work for example was affected. Buildings and extensions were being erected on every hand and for every branch of the service. Steel was hard to get, plate was at a premium and almost unobtainable at any price. Inspectors who not long before had turned up their noses at material not just up to scratch were glad and thankful to accept the very same stock without a murmur. It filled the bill and did the work without impairing the safety of the structure and that was what the inspector considered now.

It was found that flaws, seams, cracks and even pipes in material could be chipped and welded electrically or by oxy-acetylene jet. Every known means was (and is) being employed to economize material and eliminate waste and the inspector in most cases not only accepts but approves and seeks to assist in every way in this saving of material.

At the same time the standard of workmanship has not really been lowered but rather elevated by this intrusion of new work, new methods and new thought into the shops and offices of our manufacturing concerns. Ship work for instance has wonderfully increased during the past year or so in this country and probably this work has never been done in a more thorough and workmanlike and systematic manner with such a high standard of excellency and with such a small percentage of rejected material. The manufacturer and the inspector, as perhaps never before, have tried to get together on these questions and put them through as well and as quickly as possible.

Surely all this is bringing about a much more intelligent system of inspection. Dollars and cents are saved the manufacturer without the purchaser suffering in any way. Some inspectors at least seem to be learning through the war work to act on the spirit of the specifications instead of trying to stick to the letter of them. There always have been those men who have inspected in this way, but the urgency and importance of war work seems to bring it out more than ever before. May these war time lessons that each one of us have been learning at such a high price not be easily forgotten.

## A SUBSTITUTE FOR CORRUGATED IRON.

The British are now manufacturing a satisfactory substitute for corrugated iron and sheets. It is an asbestos-cement roofing material. The method of making it is as follows: After being finely ground and freed from extraneous matter the asbestos, which acts as the reinforcing agent, is mixed with portland cement in the proportion of about 1 to 6, and made into a paste with water. This paste is then taken to a machine of the paper-making type, where, on a large revolving drum, it is formed into sheets or felts. After the sheets have been trimmed to size they have the corrugations impressed on them. The important condition for this operation is to insure that the tops of the corrugations are as strong as the other parts of the sheets. Finally the sheets are subjected to a "seasoning" process. The corrugations are made to the 3 in. pitch which is usual with corrugated iron sheeting, not to the 2½ in. foreign pitch, and they can therefore readily be used to repair roofs of corrugated iron. One of the chief advantages claimed is their durability and resistance to climatic conditions, especially to an acid-laden atmosphere, which rapidly destroys corrugated iron. The sheets are also fireproof and are poor conductors of heat.—Brass World.

# EDITORIAL

## ELECTRIC SMELTING ON THE PACIFIC COAST.

The possibilities of the Pacific Coast as a site for electric smelting were described a couple of years ago by Mr. J. W. Beckman in the "Metallurgical and Chemical Engineering" for July, 1916. Mr. Beckman points out that in many respects the Pacific Coast of the United States is similar to Sweden and Norway, countries which have become famous for their electrical developments. The area of Sweden and Norway is about the same as that of the three States of Washington, Oregon and California, and the population in Sweden and in the three coastal states is also about the same.

The most essential condition of electric smelting is cheap hydro-electric power. In Norway seven and a half million horse-power are available, of which about one and a half million are now developed. Sweden has over six million horse-power, of which more than one million is now developed. On the Pacific Coast of the United States there are available about eleven million horse power, of which about one million has been developed. It will thus be seen that the possibilities of the Pacific Coast States are similar to those of Sweden and Norway.

One other advantage possessed by both localities is that of cheap water transportation. The electro-chemical works in Norway are largely situated on tide water and their products can be marketed cheaply all over the world. A similar situation exists in the Pacific Coast States. For certain industries, such as the production of calcium nitrate, very little is required in the shape of raw material, as the atmosphere forms an important ingredient and limestone is the only other necessary supply, but in most electric smelting operations some form of carbon is essential, and this is best obtained in the form of charcoal.

The Pacific Coast States have about as much timber land as Sweden, and when we turn to the coast of British Columbia we find an abundant supply of timber from which charcoal can be produced at a moderate expense. In this district we have all the elements of economical electric smelting—water powers, charcoal, and ocean transport, and it is, therefore, very desirable to look into the possibilities of electric smelting in British Columbia.

A few months before the war, Dr. Alfred Stansfield was sent by the Dominion Government to investigate the electric smelting of iron ores in Sweden, the only country in which this industry has attained commercial importance. Dr. Stansfield was fortunate in passing through Germany and visiting the Krupp Works at Essen before the outbreak of hostilities, and his report on the Electrothermic Smelting of Iron Ores in Sweden was subsequently published by the Mines Branch.

A few months ago the Government of British Columbia decided to investigate the possibilities of smelting iron ores electrically on the coast. This decision was made in view of the urgent need for pig iron and steel in British Columbia and of the presence of iron ores and electric power. The possibility of establishing a large blast furnace industry was also considered, but in view of the limited market in the West it seemed better to investigate in the first place the possibility of electric smelting which would naturally be on a smaller scale. Dr. Stansfield was appointed to carry out this investigation and has spent some time in British Columbia and also in California. Apart from Sweden the only point at which electric smelting of iron ores has been attempted on a commercial scale is at Heroult in Shasta County, California, and it was, therefore, desirable to visit the plant at which this attempt was made, although it is not making pig iron at the present time. Dr. Stansfield has now returned to Montreal and will soon present his report.

---

## SOME PROBLEMS OF MODERN INDUSTRY.

In considering the production of iron and steel in their varied forms, our attention is always directed to the technical side of the operation, and after that to the economic factors—the prices of raw materials, operating and transportation costs, and markets—in which we include the cost of labour and the interest on capital as two elements in our calculation of the problem. The supply of capital and labour, not to mention technical and business management, are not elements that lend themselves completely to mathematical treatment, and the conditions brought about by the war have impressed on most of us the need of a very careful reconsideration of the problems of employment and business management. The uncertainty of labor threatens to paralyze industry, even when this is vitally necessary for the conduct of the war or the supply of food to the allied peoples.

The war has, however, supplied us with a principle on which it may be possible to build a society that shall be more ideal and also more effective than in the past. We refer to the principle of National Service, exemplified in the army and navy, and to be worked out on broad lines for the requirements of peace. Under this principle the object and reason of all industry must be reagrded as its service to the community; the wages paid to the labourers and the technical and business staff, and the interest paid to the capital

employed are all necessary by-products which must be regulated in some satisfactory manner.

We print in this issue a paper by W. K. Hitchens, Chairman of Cammell Laird & Company, delivered before the Greenock Philosophical Society, which throws some light on many aspects of this important subject, and at the same time affords information with respect to the present conditions of industry in England and Scotland.

## CANADIAN VICKERS LAUNCH THEIR THIRD CARGO STEAMER THIS SEASON.

The successful launch of the S.S. "Sannanger," took place at the works of Canadian Vickers, Limited, on Saturday morning. This makes the third launch from Canadian Vickers' yards since the present open season of navigation.

The dimensions of the "Sannanger," which is a 7,000 tonner, are as follows:—

| | |
|---|---|
| Length | 380 feet |
| Breadth | 49 feet |
| Depth | 30 feet |

The "Sannanger" is a sister ship to the "Porsanger," which was recently delivered by Canadian Vickers, Limited, to Messrs. Furness, Withy & Co., of Montreal, who are acting as managers on behalf of the British Government.

It is expected that the "Sannanger" will be completed within two or three weeks.

The vessel was launched by Captain H. Jonassen, of Bergen, Norway. As in previous cases there was no ceremony.

The rapid production now going on at these works was strikingly evidenced during the launch. On the dock their latest ship, the "War Earl," was being painted after having run her steam trials last Thursday, while the sister ship, "War Duchess," was lying in the basin with all machinery on board, getting ready for trials to take place in about two or three weeks.

There is, therefore, every indication that at the end of the present month Canadian Vickers' yard alone will have completed and handed over, four 7,000 ton cargo steamers, while on the berths there will be five other vessels, several of them in an advanced stage of completion.

## FERGUSON STEEL BUILDING SHIPS.

Keels for the first two sea going tugs were laid last week at the new Ferguson Steel & Iron Company Shipyard on Abbott Road, Buffalo, New York. The Ferguson Company has a contract with the Navy Department of the Government fo rthe construction of six sea going tugs 150 feet long of 1,000 ton burden. They have also received a contract from the Government for the construction of twenty-four barges for use on the New York State Barge Canal. The tugs will have engines capable of generating 1,800 horse-power, but the barges will not be provided with motor power.

The Ferguson Shipyard covers thirty-two acres of land on Abbott Road, adjoining Buffalo River. The shipyard is strictly modern in design and layout and all plans have been formulated with the one idea in mind of turning out the boats as quickly as possible to meet the exigencies of the Government.

The office builidngs at the yard are completed, the Power House is in operation, and the warehouse, Woodworking Shop and Machine and Metal Shops are under construction. Tracking facilities have been provided and actual work on the first two tugs has been started. The thirty-two acres of the shipyard added to the acreage of the main plant on Bailey Avenue gives the Ferguson Steel & Iron Company about sixty acres for their operations. This acreage allows of expansion which is bound to come at the shipyard as it has come to the main plant. The main plant on Bailey Avenue is now thirteen times as large as it was at the beginning of the company in 1913, not a month having passed during the last five years but what some improvement has been made at the Ferguson Plant.

Captain James E. Ferguson, President of the Company, is said to be mainly responsible for the wonderful growth of this new steel concern. He is a western man, with the typical western progressiveness, and has caused considerable favorable comment by his remarkable success in the steel business.

Mr. Edward P. Butts, an engineer of considerable note, is general manager of the shipyard and is busy perfecting his working organization, which will consist at first of about 700 men.

The model of the barges to be built by the Ferguson Steel & Iron Company was made in the template shop by Ferguson men, and most of the changes suggested by them have been accepted for use in all the remaining barges to be built. The Mold Loft, Plate and Angle Heating Furnaces, Bending Rolls and all other equipment necessary for the fabrication of the ships has been installed at the Ferguson Plant, and is in operation. The barges will be 150 feet total length with 115 carrying length. Each barge will contain about 60,000 rivets. The ends of the barges will be exactly alike, but will not be the typical square end barges used so long on the canals of this country. The molded ends have been designed for purposes of fast fabrication and are proving practicable.

The entrance of the Ferguson Steel & Iron Company into the shipbuilding business places Buffalo among the leading cities in this very important industry. Several other shipbuilding plants are located in Buffalo and men by the hundreds are being attracted to this industrial centre by the wonderful opportunities offered to do a patriotic and profitable service. The shipbuilding business seems bound to progress for many years to come, even after we have won the war, and the Ferguson Steel & Iron Company is planning for the future, at the same time rushing the boats required by the Government for immediate use.

## HAMILTON NOTES.

On July 1st the name of "The Dominion Steel Foundries" was officially changed to "Dominion Foundries & Steel, Limited.' This name is really much more appropriate, as steel casting is getting to be a comparatively small part of their business. They do a big business in their plate mill, as well as in their rolling mill for bars, etc. They have already commenced operations in their large new building recently erected for big shells and the old plant of the "Hamilton Steel Wheel" which has been absorbed by the Steel Foundry is also filled with presses for shell work.

"The Dominion Foundries and Steel" are rebuilding their oil storage tanks and encasing them in concrete. They have two tanks of one hundred thous-

and gallons capacity and one of two hundred thousand gallons capacity. They are also erecting a new tank which will be similarly encased in concrete.

This firm is also building a new continuous heating furnace, of a very modern type, to take a double row of billets. It is hoped this will be in operation some time next month.

Rather to the annoyance of some of the city officials perhaps, the outside civic employees recently held a meeting under the auspices of the Trades and Labor Council for the purpose of organizing a civic union, which it was decided should be affiliated with the American Federation of Labour. The president and secretary of the Toronto Civic Employees Union were speakers at the meeting. The recent trouble among the Toronto Civic Employees doubtless was largely responsible for this move, but it is indicative of the more or less general. state of unrest of labor at present.

The urgent need for small houses in the city for workingmen was discussed at a meeting of the Hamilton Board of Trade early this month. The town planning commission have brought in a report, recommending the erection of houses that will rent from $15 to $25 per month and sell at $2,300 to $2,700. Mr. E. Wilson, representing the Merrill System of apartments addressed the Board. Mr. R. T. Kelly, the President, was authorized to name a Committee of the Board to act with the Joint Housing Committee of this city.

The City Building Inspector, Mr. W. J. Whitelock, also emphasizes the need for small houses or apartments. This, he says, is about the only class of building going on this year in the city.

It is interesting in connection with the above to note the action of the Ontario Government in this matter, made public in a letter from Sir William Hearst to Sir John Willison, Chairman of a recently formed housing section of the organization of resources committee. In this letter it is proposed as a temporary measure of relief that the provincial government establish a loan not exceeding $2,000,000, of which any municipality may avail themselves under certain liberal terms for the erection of houses not to exceed in cost $2,500 or to rent for more than $25.00 per month.

Sir William points out in his letter that the question is one upon which the Federal and Dominion Governments both should take a certain amount of responsibility, as well as the municipalities, inasmuch as it is to a certain extent a war measure as well as an industrial and national one. In making this offer, it is pointed out that it "must not be considered as an admission of responsibility on the part of the province, or in any way relieving the federal government or municipalities, employers of labour and citizens generally from whatever obligations may rest upon them to provide a satisfactory solution of the whole question. The object of the government is to lend some assistance regardless of where responsibility rests, with the hope of stimulating effort on the part of all parties concerned."

It is interesting to note that this loan, as well as assisting the manufacturers, also applies to farm labor.

The housing problem is also acute in Toronto, Sault Ste. Marie, Guelph, Galt, Brantford, Welland, Sarnia, Midland, Hawkesbury, Paris and Sudbury.

The City Council of Hamilton expect shortly to take up the matter and a conference on this question has been arranged for here. Mr. Thos. Adams, of Ottawa, Town Planning Advisor, and Prof. Sissons of the Ontario Housing Committee have been invited to attend. It is expected that the Board of Trade, Trades and Labor Council, Manufacturers' Association, Town Planning Commission and City Council will all be represented at the Conference.

The Government announcement of the new loan has been a source of much satisfaction in the city.

The Canadian Hart Wheels have removed from their old premises on Barton St. East, to the plant vacated by the Monarch Metal Co. (formerly the Hamilton Brass Co.), who are moving to their new plant on Main St. W.

Goldie McCullough Co. of Galt., Ont., have the contract for the boilers, and installation of same, at the Beach Pumping Station at a price of $17,759. Babcock & Wilcox had been awarded this contract at a slightly lower figure but, owing to war conditions, the Government would not permit them to proceed with it on account of the need of material in the Old Country.

It is hoped the new Coke Ovens of The Steel Company of Canada (under construction by the Wilputte Coke Oven Corporation) will be ready for operation by the beginning of November. The Steel Co. recently extended an invitation to the Hamilton City Council to visit the plant and inspect the new coek ovens.

The City of Hamilton has had under consideration the installation of municipal coke ovens in order to relieve the gas situation. An eighty oven plant was being considered which it was estimated would give a supply of 8,000,000 cu. ft. per day. By-products in the way of coke, ammonia, etc., would help with the revenue; it was expected about 12,000 tons of coal per day would be required and about 8,000 tons of coke be recovered as a by-product. The cost was estimated at over $2,500,000. After careful consideration and investigation, we understand the scheme has been definitely rejected.

The National Abrasive Company expect to leave the city. They have had considerable trouble of late with lawsuits from those in the neighborhood, due to abrasive material being emitted from the plant. The company has an option on a site in Renfrew, but nothing definite had been decided on up to the time of writing. We understand the plant here will not be removed, as it is purchased by another concern.

A high phosphorus iron will generally have less tendency to absorb sulphur from the coke than a low phosphorus iron.

It is a noticeable fact that foundry foremen are very unwilling to admit criticism of their iron as it comes from the cupola, and perhaps this proceeds very naturally from their knowledge that at that stage it is impossible to alter it in any way, and that it is their duty to make the best of it whatever its condition.

Somewhere between 30,000 and 35,000 cubic feet of air are required per ton of iron melted in a foundry cupola.

# Defects in Steel Ingots

By J. N. KILBY (Sheffield).
English Iron and Steel Institute.

Annual Meeting, London, May 2-3, 1918.

At the September meeting of 1916, and the May meeting of 1917, at this Institute, papers were presented by me dealing with defects found in steel ingots or in the article manufactured. Papers upon the same subject have also been read before the Sheffield Society of Engineers and Metallurgists, and the Staffordshire Iron and Steel Institute. In this present paper it is intended to extract some of the matter given in the two last papers, coupled with further observations and results.

### Previous Conclusions upon Influence of Casting in Relation to Cracks in the Ingot or Bar.

It is generally accepted that the important factors are:

1. Temperature of steel at casting.
2. Speed with which the mould is filled.

Other yet lesser factors are:

1. Whether the ingot is bottom or top-poured.
2. Size and weight of the ingot.
3. Cross-sectional area compared with length.
4. Composition of the steel.
5. Weight of steel to be cast from the ladle.

**Temperature of the Steel.**—Different opinions still exist as to the present value of pyrometry in controlling the furnace product. In November last this variance of opinion was obvious at a gathering of experts upon the subject (Faraday Society). I give here some views upon the matter, which at the least do not agree.

Dr. Rogers, in his criticism of my last paper in May, says " that a good deal could be done with the aid of pyrometers, but that he had not found them to be sufficient in themselves, and that his own efforts in the direction of inventing a pyrometer to overcome the limitations involved were not as yet completely successful."

He further states that " he quite well knew the temperature of the bath, vision also being supplemented in many practical ways, so that control and investigation of the process presented no difficulty in that respect." No doubt a good deal can be done when the temperature of the steel in the furnace can be determined accurately: it is not much that divides, but, unfortunately it is the mainspring of the whole. High temperature just prior to tapping can then easily be adjusted by additions of scrap.

Mr. Service thought I relied too much upon what he termed " experience and eye method." The opinion of Mr. Service is very interesting when compared with the following extract from Mr. Cosmo Johns' paper, published in the Iron and Coal Trades Review for November 16, 1917:

" It was found that a skilled observer could, with the aid of blue glasses from observations of the steel as it is poured from the furnace into the ladle, estimate differences of possibly 10°, and certainly 15°, apparent temperature; while men, watching the pouring of the steel from the ladle into the moulds, where the increased viscosity, due to decreased temperature and other factors, rendered possible a greater precision in the estimate, could certainly distinguish differences of 10° apparent temperature. Any pyrometer adopted must therefore be capable of giving consistent readings with greater precision than 10°. As a matter of fact, a trained observer can, with a suitable instrument, obtain readings with a variation of 2.5° under very favourable conditions, and this degree of accuracy is more than sufficient for effective control of the metallurgical processes employed. For each class of steel it is only necessary to determine—for the particular casting method employed — the ' normal ' temperature when the steel is tapped from the furnace, which gives the best result. This ' normal ' may vary as the process employed is modified. The measurements involved are therefore divergences from the particular ' normal ' adopted at the time, and as the range of variations in regular practice is small, no appreciable error is introduced by considering the differences in the pyrometer readings as temperature differences. The desirable temperature varies 10° apparent from the normal, and a very high percentage of the casts does not appreciably exceed these limits. Temperature variations of 20° apparent give rise to serious difficulties, and 15° apparent can be considered to be the variation admitted in practice. These limits are for special steels; they are wider for ordinary commercial steels."

A statement by Dr. W. Hatfield on "Pyrometers from the Standpoint of Ferrous Metallurgy," published in the Iron and Coal Trades Review for November 9th of last year, may be of interest at this point:

"Although the temperature at which steels are cast must have an influence upon their ultimate physical properties, no ready or really reliable method for measuring such temperatures from the works standpoint is available. This is a considered statement. It would obviously be of considerable use if the temperatures of successive heats of steel could be controlled and determined."

When one speaks of casting temperatures, the terms hot or mild are purely relative to the product desired, though they are often used without full regard to accuracy. For instance, a cast alleged to be on the " hot " side may produce ingots free from cracks provided the period of filling be prolonged to the correct extent by using correct sized nozzles, or secondary ladles, or, when bottom-casting, putting down a sufficiently large number of ingot moulds per bed. Further, a cast alleged to be on the cool side will most certainly yield ingots which will crack at cogging, if they have been teemed relatively quickly.

Teeming speed is really of greater importance than temperature, taking the variation from one cast to another to be within usual everyday practice, and omitting exceptional cases of hot steel caused by careless manipulation.

Of all trades and processes the steel trade stands first in its dependency upon the personal equation and the whole business appears to be one compromise after another. The only direction in which we can work is to avoid all unnecessary complications, and to provide methods possessing the widest margin of safety.

Argument upon casting temperatures would lead one to suppose that the difference in degrees of heat was extremely great. Experience proves that this difference, coupled with the factor of safety, is not great. The casting of heat after heat with a slight skull left behind, at the same time getting cracked ingots in the mill or forge, points to the great importance of correct teeming speed per ingot. Speaking of casting temperatures and skulls, a case occurs to my mind of the principal of a firm who insisted upon the necessity of cool steel, asking for confirmatory evidence in the form of a certain minimum weight of skull (5 cwts.) each time. After numerous too successful attempts at the weight desired (very often resulting in the loss of the entire cast) someone discovered that, by ramming

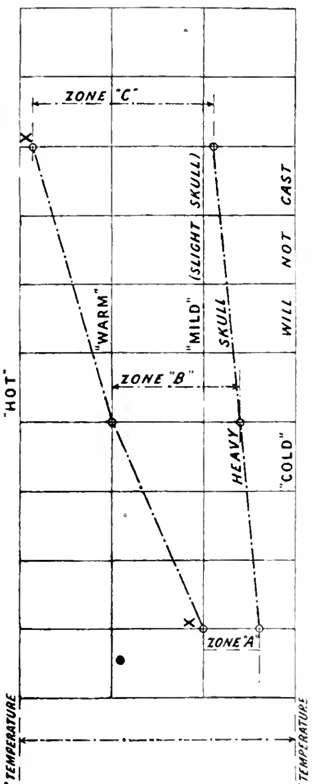



FIG. 1.—Chart 1. Zone "A."—Nozzle, $1\frac{1}{4}$ inch. Where the ladle, running at full stream above the capacity of the ingots upon the bed, and the rate of filling depends upon the teemer using stopper throughout.
Zone "B."—Nozzle, $1\frac{1}{8}$ inch. Where the number of ingots per bed is just under the capacity of the ladle, casting at full stream.
Zone "C."—Nozzle, $\frac{7}{8}$ inch. Where the nozzle size and the capacity of the ingots on the bed balance when casting full stream, the steel tending to freeze slightly on the surface during filling.

or bricking the ladle bottom in a direction sloping away from the nozzle, a skull of a consistent weight could be obtained every time, even on the warmest of casts, but all casts were thereafter accepted as cool.

Bottom Cast Steel.—The objects achieved by bottom casting are:

1. Better surface of ingot.
2. Less splash.
3. Freedom from cracks during working.

The first two items are generally obtained, but the third is dependent upon factors already detailed. There are a good many objections to the bottom casting of steel, the danger of the extraneous inclusions being far greater than is the case in top casting.

It is possible to cast groups of ingots from the same heat and have a number of them work while others will be very badly cracked.

It will be seen that casting through varying sized nozzles, or varying weight per bed, one may easily obtain great differences in the actual time required to fill each ingot. The time factor governs the first formation of solid steel, and decides whether the later contraction will crack the ingot or not. The steel should not fill the mould in too free a manner, but should tend to scum over and gradually and evenly form a thin cover of semi-solid steel from the bottom to the top as the filling proceeds.

| | | MINUTES | | | | AVERAGE NO. OF CASTS |
|---|---|---|---|---|---|---|
| A | TIME EACH INGOT | 1½ | 2 | 2½ | 3 | 10% |
| | DEFECTS AT MILL | 20% | 10% | 5% | 3% | |
| B | TIME EACH INGOT | 2 | 2½ | 3 | 3½ | 5% |
| | DEFECTS AT MILL | 10% | 5% | 3% | 2% | |
| C | TIME EACH INGOT | 3 | 3½ | 4 | 4½ | 1% |
| | DEFECTS AT MILL | 2 | 1 | RARELY CRACK | | |

FIG. 2.—Chart 2. Showing Yield of Sound Steel free from "Cracks" in Rolling. To be read with Chart I.

If one casts a charge of steel in the following manner:

| | |
|---|---|
| 1st bed.................... | 6 ingots |
| 2nd bed.................... | 5 ” |
| 3rd bed.................... | 4 ” |
| 4th bed.................... | 3 ” |
| 5th bed.................... | 2 ” |

with a similar stream from the ladle in each case, the result would give a variation in percentages of defects to the proportion of increase of the speed with which the moulds filled (see Fig. 2). Cheese tires amply prove this, e.g. I found that in casting 480 lb. cheese tires the percentages of defects were as follows:

¾ min.............All cracked under press.
1 min.............50 per cent cracked under press.
1¼ min.............25 per cent cracked under press.
1½ min............. 5 per cent cracked under press.
1¾ min............. 2 per cent cracked under press.
2 min. and over...None

Again, with regard to tire steel, where ingots are sliced into blocks and afterwards, etc., varying results may be obtained upon the selfsame ingot, due to erratic teeming, as indicated by Fig. 3.

Regarding the base or bottom portion of any bottom-poured ingot (where a good percentage of defects will show, if visible anywhere), it is important not to rush the first foot of the ingot during teeming.

Variation in the teeming speed either in the individual groups of ingots, in a cast, or from one cast to

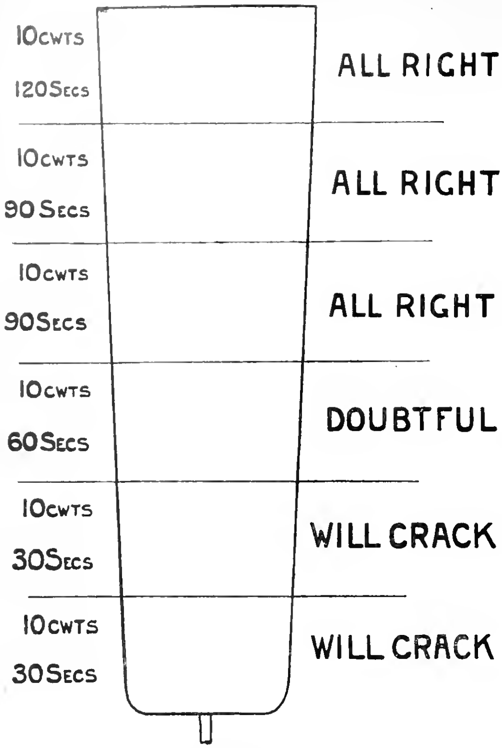



FIG. 3.—Three-ton Ingot to be cut up for Tire Blocks. Total teeming time, 7 minutes. Top half passable, bottom half sure to crack. (Where nozzle full stream exceeds capacity of ingot.)
As shown the time varies for each 10-cwt. portion and would result in defects according to time taken for each portion, accounting for a number of bad blocks in indiivdual ingots.

another, is therefore to be brought to a minimum. There is a definite time per ton for any mould: above this time no cracks result, but below it trouble begins, in spite of "cool" steel.

From the foregoing remarks relative to bottom-cast steel, the logical conclusions to be deduced are: that the pitman must be in such a position that he cannot possibly teem too quickly, and that the speed must be such as to be safe, yet so regulated that the cast can be successfully dealt with. Where slow teeming depends entirely upon stopper manipulation erratic results are certain.

Top-Poured Steel.—Certain classes of steel are cast to advantage by being top poured. Such material is always freer from extraneous inclusions and shows fewer defects from this cause when the ultimate article has to be machined and closely scrutinised. The compensating disadvantage, however, of top pouring steel is the greater liability of obtaining cracked ingots. In many cases no regard is paid to the actual time taken in filling the moulds or finding the speed most conducive to correct results.

Speed in filling the mould is the most important factor at any time in the process of steelmaking. Provided that the speed of a top-poured ingot compares equally with a bottom-poured one, similar in size, corresponding results can be obtained as far as freedom from cracks or rokes are concerned.

When top pouring, the flow of the steel tends to force any particles of extraneous matter to the sides of the ingot, thus making a purely surface defect, as compared with an embedded one in the case of bottom pouring.

When taking teeming times the period should commence from the moment the steel enters the mould to the instant that "feeding," as it is termed, takes place. Two ingots may be teemed, the total time being equally divided between them, yet one may be sound and the other may work badly: the reason for this being that the time taken by the latter may have been spent, not in casting the ingot proper, but in feeding the last portion. The smaller the ingot the greater the comparative necessity of top pouring correctly.

It is somewhat striking to note the difference one finds in teeming speeds, for a given weight, at different works. For the same quality of steel in a 65-cwt. ingot, teeming times varying from one minute up to ten minutes for the whole ingot have been noted.

Dr. Burgess, in his communication on Brearley's paper,[1] gives his time for teeming a 7200-lb. ingot as one minute. Taking a similar ingot my experience is that, when teemed under three minutes, 80 per cent will show cracks at rolling, the safety line actually being six minutes.

Lappiness.—Bottom-poured steel cast at too low a temperature or too slow a speed tends to cause lappiness, or folds, in the ingot. Ordinary carbon steels do not suffer much from this condition for the reason that, should the steel be so cool as to lap badly, the chances are much against the mould filling at all.

Chrome, high-silicon, and vanadium steels are always subject to lappiness in a more or less degree. The appearance of the ingot will give some idea whether this lappiness is going to be a serious defect or not. If the teeming is so slow as to allow the steel to form a solid cake or cover, through which it afterwards bursts (and this frequently occurs in this class of steel), the result will be sufficiently serious to attract notice later, when machining. The formation of oxide films on the surface of such slowly cast ingots tends to give fine elongated seams or pockets when the steel is rolled. The use of pitch, ground as fine as flour, in the mould as the steel rises, must necessarily help to minimise the danger, as also the tarring of the mould. An ingot scumming over too quickly will clean itself with a minute proportion of such pitch.[2]

It is evident, therefore, that in the case of some steels there is a minimum rate below which the teeming must not drop.

The use of comparatively large nozzles in the ladle and a small weight per bed lead to what I term spasmodic teeming, the stream from the ladle running at full force being of greater volume than is compatible with the correct filling of the moulds. In these cases the teemer has to use his discretion and endeavour to control the stream so as to fill the moulds correctly. Often the result is an ingot teemed in widely varying

[1] Journal of the Iron and Steel Institute, 1916, No. II, p. 180.

[2] The use of anthracite for this purpose is fraught with great danger and should never be resorted to.

speeds and lapped in a good many places, the stream being often momentarily cut off.

### Composition of Slags of the Different Steel-Making Processes, Their Physical State, and Relationship to the Ultimate Product.

Acid Open-Hearth.—In the May paper of 1917 a number of charts were given along with certain facts illustrating the effect of lime upon slag composition and the resultant physical conditions of the acid open-hearth process. It was my argument, based upon analyses and records, obtained from different works, and extending over a period of more than ten years, that the use of limestone or similarly constituted basic material, was highly essential to the success of the process. That, with a slag containing certain percentages of lime, the danger of slag inclusion resulting from retained oxides, silicates, etc., was to a large extent minimised, at any rate, as far as furnace control could go. Further, that this was brought about by the lime slag being in a perfect state of flux, thus yielding more suspect bad cases of the trouble in question, viz. slag inclusions. The influence of CaO upon the manganese yield is very marked. Including all variables, particularly the time factor, and basing the figures given upon data extending over a huge number of casts, the relationship may be described thus:

> The yield of manganese obtained in the steel in the bath, from added ferro-alloys, all variables considered, is proportionate to the CaO per cent (or its equivalent of similar basic material) in the slag. See Fig. 4a or Fig. 5.

It will be noted in Fig. 5 that the manganese yield obtained increases with the CaO per cent in the slag. The curve is derived from the results of average casts, with varying CaO per cent. The difference as shown is about 20 per cent, or in the actual figures 0.18 per cent manganese. In establishing the records identical conditions (excepting CaO content) were aimed at, the time factor receiving the greatest care. I was shown some interesting figures recently, proving how defects

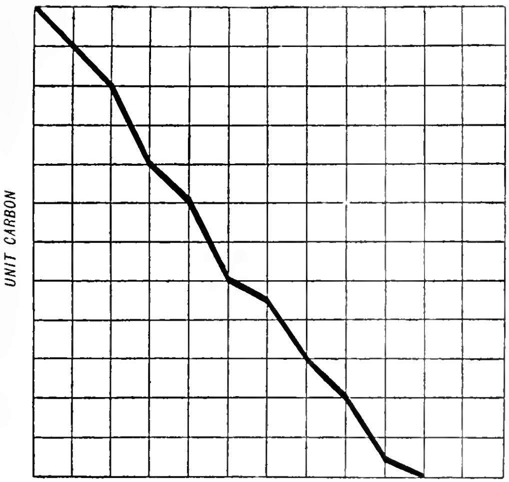
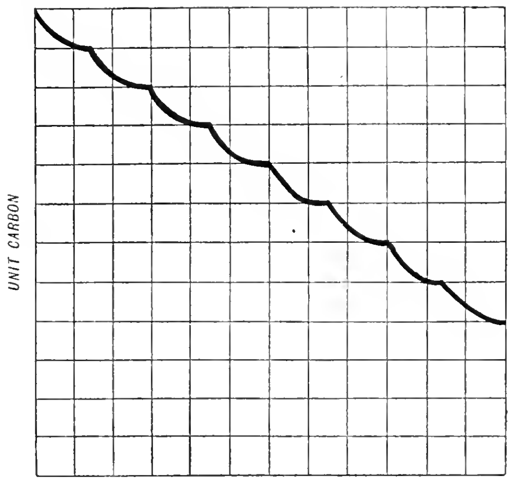



FIG. 4a.—Units of Time.
Where insufficient CaO or no CaO is used. Showing erratic fall in carbon and consequent conditions at finishing.




FI 4b.—Unts of Time.
Where the slag contains throughout the correct CaO per cent. Showing correct bath condition at any period of the boil.

intimate contact with the steel, and a state of receptivity for such undesirable inclusions referred to. Reference was also made to the control of carbon elimination. See Fig. 4.

Fig. 4 shows two diagrams:

(a) Charge worked throughout without CaO.

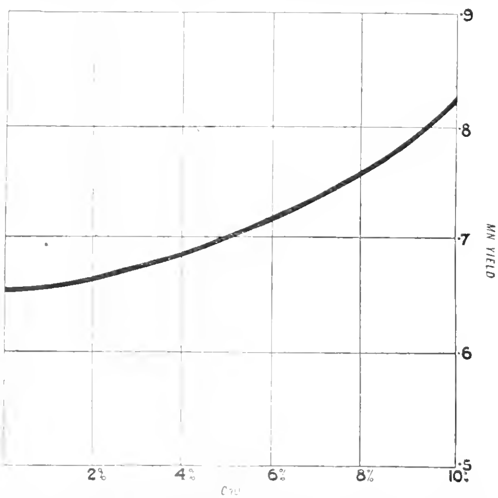
(b) Charge worked throughout with CaO.

In the first diagram (the charge without CaO) it will be noted that the fall in carbon is erratic and for a given time varies greatly. The bath at any stage would not be in a reliable condition, and naturally such heats usually vary in the finished results as far as analysis goes, apart from the other and greater evil of doubtful steel. In the second diagram, where CaO has been introduced from the beginning and maintained throughout the process, the carbon elimination is more regular, and a charge could be tapped almost at any period without fear of very wrong results analytically. Consistent results from finishing material added are more readily obtained. Where large losses of manganese take place at the finishing stages, one may due to slag inclusions in certain classes of ingots ran in the inverse ratio to the loss of manganese in the bath, or corresponding increase of MnO in the slag. There was naturally a decrease in the FeO present. The dominant feature governing the whole was, without doubt, the CaO per cent in the slag at tapping.

"Dead melting," so often referred to, can be obtained at any period of the process after boiling, if the two factors, of available silicon and silica of the charge, and that of lime content of the slag, are duly considered and worked to. The slag or refining medium of the process is almost purely a product of the metals, metalloids, and their oxidation during melting and working, and as a consequence it is liable to vary somewhat according to the constitutents of the charge and the time requisite to reduce the mass to the molten state. Consistent and reliable results therefore would not accrue, unless some basis is aimed at, to fulfil the functions most desirable. The fact that material is made and passes specification, ignoring the above, is not argument against its adoption. Standardisation

is [illegible] essential where so much depends upon the personal element of the workman. Material of just as good quality can be made with only moderate percentages of pig iron in the charge, providing the ruling factors are fully appreciated; also, the use of high percentages of pig iron does not necessarily overcome the difficulty of over-oxidization. Fig. 6 shows a charge illustrative of the effect of great excess of oxide present. The charge consisted of 20 per cent. pig iron, containing 2 per cent silicon, and 80 per cent scrap (including 10 per cent poor steel turnings). No added slag.

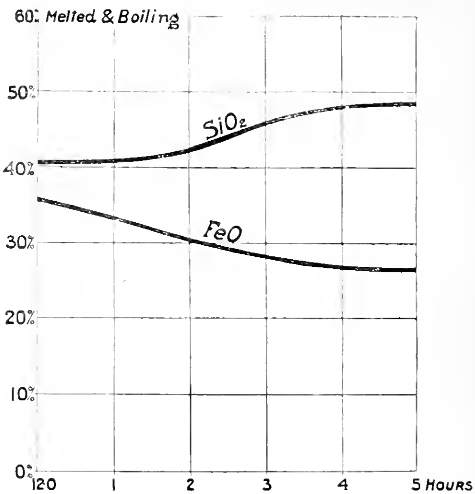
As the chart (Fig. 6) indicates, the heat worked badly and with a poor slag throughout. The example is given as an exaggerated case of what I refer to, sufficiently bad indeed as to govern its relegating to the scrap-heap. Between such a case as this and ideal casts, however, I maintain there is a long range, productive of doubtful results, though not sufficiently bad to reveal their gravity, until the ingots has been fur-




[illegible] 7.—To show relationship between Mn yield into the Steel, [illegible] the percentage of CaO in the Slag. All varying factors of course [illegible] considered.

ther manipulated. The shortage of pig iron, and the necessity of drawing from the dump scrap-heap, point to the advisability of adopting some means of control of regular melting. Works possessing unlimited supply of good scrap are not so badly placed as those dependent upon any possible outside source of supply.

Dr. McCance, in his criticism of my paper of May 1917, was of the opinion that charges possessing some of the properties of the instance given in Fig. 6 were [illegible] and that quick hot melting [illegible] evil. The charge in question was [illegible] in 6½ hours, which I believe is [illegible] other practice in this country for similar [illegible] heats, [illegible] 40 tons. Fig. 6 amply illustrates the [illegible] of residual "oxides" and one origin of slag [illegible]. No [illegible] sufficient oxide being [illegible] more than remove the [illegible]. The [illegible] losses in the added finishing [illegible] composition speak for themselves. [illegible] that this particular heat re-




| TIME | FEEDS | | | CARBON | SILICON | TIME | FEEDS | | | CARBON | SILICON |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ORE | LIMESTONE | PIG IRON | BATH SAMPLES | | | ORE | LIME | PIG | BATH SAMPLES | |
| 12.0 | - | - | | 1.00 | .010 | 2.30 | - | 5 cwt | 5 cwt | .26 | .030 |
| 12.30 | - | - | | .90 | .010 | 3.0 | - | - | | .21 | .030 |
| 1.0 | - | - | 5 cwt | .70 | .018 | 3.30 | - | - | - | .17 | .027 |
| 1.30 | - | - | 5 cwt | .55 | .026 | 4.0 | - | - | - | .17 | .030 |
| 2.0 | - | ½ cwt | 5 cwt | .37 | .026 | 4.30 | - | - | - | .17 | |

FIG. 6.—Finishing added in Bath: FeMn in bath five minutes. Theoretically: Carbon, 0.15; silicon, 0.15; manganese, 1.10. Practically. Carbon, 0.06; silicon, 0.10; manganese, 0.63. To show bad case of over-oxidised charge during melting. Also conditions subsequently and analyses of steel, etc.

quired a heavy dose of ferro-silicon or high silicon pig iron to overcome partly the abnormal conditions prevailing. This again confirms the necessity for due consideration of available silicon and silica in the charge.

There is still some difference of opinion about the use of such basic material as CaO or MgO in the acid open-hearth process, as well as the quantity to add and the periods at which such additions should be made. From results obtained, I contend that 8 per cent. to 10 per cent. in the case of CaO, and rather less where MgO is used, say, 6 per cent. to 8 per cent. are productive of best results. MgO appears to be keener in its functions than CaO. The effect in each case, however, I believe to be similar. The periods to add were given in the May paper, also some of the reasons why.

The principal aim of the use of CaO is not to thin the slag. As the diagrams showed, it is a decided advantage to add the main portion of the CaO any time after boiling or even at melting, excepting of course the occurrence of some other abnormal condition preventing its use. The accepted benefit of the use of CaO at the end of the process confirms my argument as to its values early on. The functions of CaO are:

1. To enable the FeO present in the slag to react upon the carbon in the bath by virtue of its intimacy, physically, due to the perfect state of flux the slag assumes.

2. Whether the charge is just melted, boiling or at any stage, the addition of CaO immediately affects the composition of the slag in similar degrees and tends to remove excess oxides.

3. That the point contended of slag alteration, and the immediate decrease of FeO in the slag, produce a more absorbent medium for any extraneous matter present in the steel.
4. That CaO is not added to thin the slag.

The elimination of any element or compound impurity from the metal into the slag or flux of almost any metallurgical refining process depends upon:

A. Temperature.

B. The receptivity of such slag or flux for such impurity.

Furthermore, the last traces of impurity are usually most difficult of removal. Consider for a moment, that in the case of particles of included matter in the steel, the loss of defective material through this cause is, comparatively speaking, only a very small proportion by weight. In the case of the acid open-hearth also let us consider that we are trying to remove traces of compounds somewhat similarly constituted chemically, to the envelope by which the molten metal is surrounded. Reference is made here to the sectional diagram of the acid open-hearth bath (Fig. 7). When new the hearth proper is composed, or should be composed, of semifused

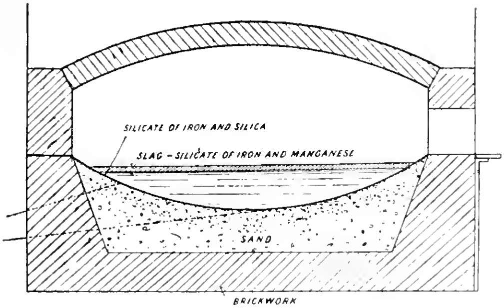



FIG. 7.—Section of Acid-lined Furnace.

$SiO_2$ plus small percentages of oxides of alumina and iron. This assumes before charging the appearance of an almost white semi-glassy mass. In this condition it is in a highly absorbent state, and continues to take from the charge a large amount of oxides (not metallic matter) until the bottom becomes satisfied or completely impregnated. By this means the hearth becomes a most important source of influence upon the working of the steel and its ultimate composition, and possesses some relationship to certain classes of defects. There is a stage, usually after the first few heats, when the hearth, satisfied with oxides, reverses to some degree the action, relieving minute particles of non-metallic matter which are taken into the steel. The elimination of any such matter can only be effected through the absorbing properties of the slag, at least in so far as the furnace operations are concerned. The composition of the slag, and its physical state, must therefore be so constituted as to aim at this desired and necessary form.

Thus far I have dealt with oxides formed during melting or introduced during boiling, and their possible elimination, by means of the slag influence upon them. Under good conditions, however an appreciable residual amount not removable in the furnace remains in the steel. Commercially we may have steels termed free from the evil, which in point of fact are not. The amount present in such instances is sufficient to affect tests, or the speed of solidification and size of the ingots and the requirements of the manufactured article do not reveal but tend to hide its presence. Small ingots retain the inclusion disseminated fairly even throughout the mass, the chilling effect of the mould preventing liquation of the particles. In the case of large ingots the reverse is experienced. A cheese tire ingot, for example, is subject to what I may term direct chilling solidification, or in other words, the mould influence outweighs the heat above freezing point possessed by the steel in the mould. Taking such an ingot, weighing only a few hundred weights, and comparing it with one weighing about 25 tons, the actual time of solidification in the former case is in minutes, and in the latter many hours. We find therefore that weight and cross-sectional area of the ingots have their own particular influences upon the locality of the inclusions. See Figs. 8, 9, and 10.

The article to be manufactured and the processes through which it passes are important points bearing upon the subject. With small forgings or stampings in special steels, or highest grade wire, every few pounds of the whole cast is put practically to close physical and other tests, whilst close machining also tends to reveal defects of minute proportions yet sufficient to cause rejection and failure. The inevitable residual slag inclusions found in the ingot and not removable in the furnace present a difficulty worthy of overcoming. To cast the steel in such a manner as to bring the whole in direct contact with some absorbent flux either in the ladle or a secondary ladle, or in the mould, would possibly prove a successful course. Some essential basic fluxes have great affinity for oxides and silicates of iron, manganese, and aluminum, and the contact of the steel with such during the process of casting would certainly be at the least partially successful. It will be often noted, when casting steel by the ton-dish method, that a good deal of extraneous matter rises to the surface of the steel, due to giving up of matter previously held in suspension. The experiments made in the direction named do not warrant more on the subject at present, but certainly give incentive to more investigation.

## BASIC OPEN-HEARTH STEEL, WITH SOME REFERENCE TO THE ELECTRIC PROCESS.

### INTRODUCTORY.

During the last three years particularly the growth of the electric process of steel-making has been nothing less than phenomenal. No one can dispute that the electric process can produce material easily, which in our acid or basic open-hearth would present considerable difficulty.

Of the many claims of the process, freedom from slag or gases has been most prominent. Correct manipulation will most probably justify this claim, but material is sometimes made which, as regards defect, rivals that by any other process. This defective material has been obtained naturally by wrong manipulation and the non-fulfilment of the principles of sound steel-making, and the faults is not attributable therefore to the process.

The defects from which our basic open-hearth steel suffers are due to similar causes as in the case of the electric process. That high-grade material can be made and is made on the basic hearth is undoubtedly correct. Numbers of otherwise practical men couple thoughts of basic steel with the inseparable phosphate

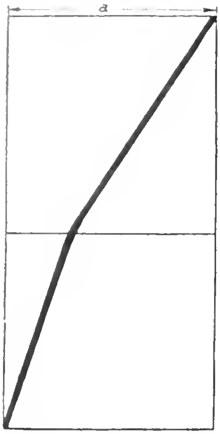



Fig. 8.—Cheese-tire ingot, where the entire ingot is solidified by direct cooling of the mould itself. Inclusions finely disseminated.

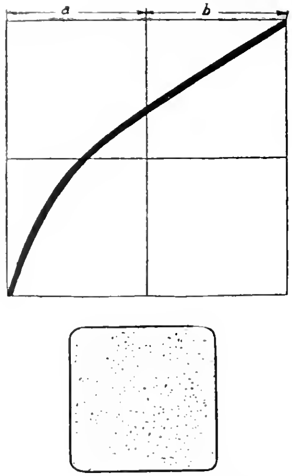



Fig. 9.—10-inch square ingot, where a large portion of the ingot is "chilled." Inclusions fairly well distributed.

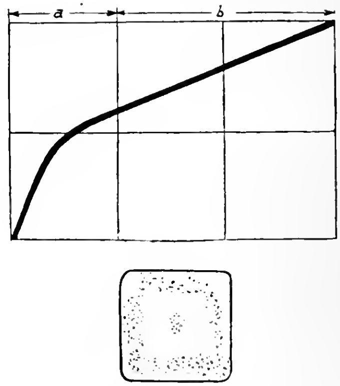
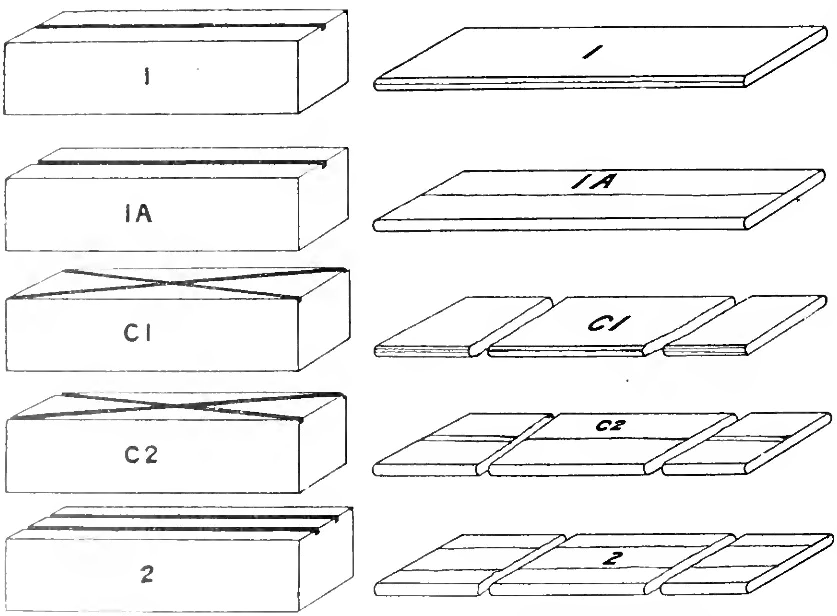



Fig. 10.—14-inch square ingot, where about one-third of the ingot is "chilled." The "dotted" area in small bars from the ingots show where the inclusions would be located.

Figs. 8, 9, and 10.—"*a*" shows proportion of the ingot solidified by the "chilling" effect of the mould; "*b*" shows proportion of the ingot solidified by "radiation." The curves show rate of solidification of the whole ingot. The slag particles are fairly evenly distributed in the "chilled" area, but are found more "locally" in the more slowly solidified steel.




Billets cut, as shown.

. Spring Bars, showing defects.

Fig 11 — To show 4-inch by 3-inch billets cut where marked to a depth of $\frac{1}{8}$-inch and afterwards rolled, to show how defect develops. To illustrate the effect of rokey billets.

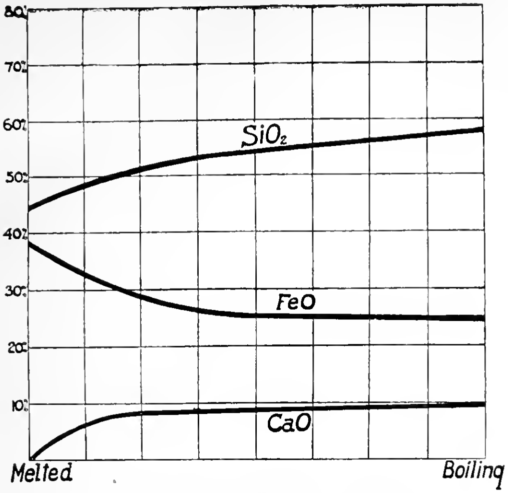
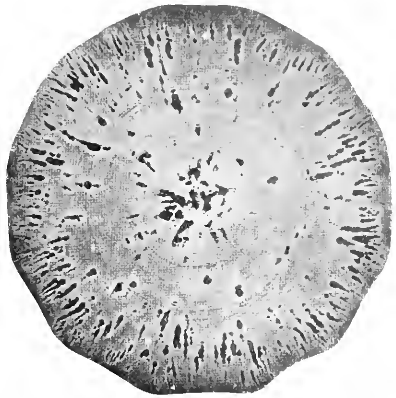



Fig. 12.—Showing how addition of CaO during period of melting to boiling influences slag composition.

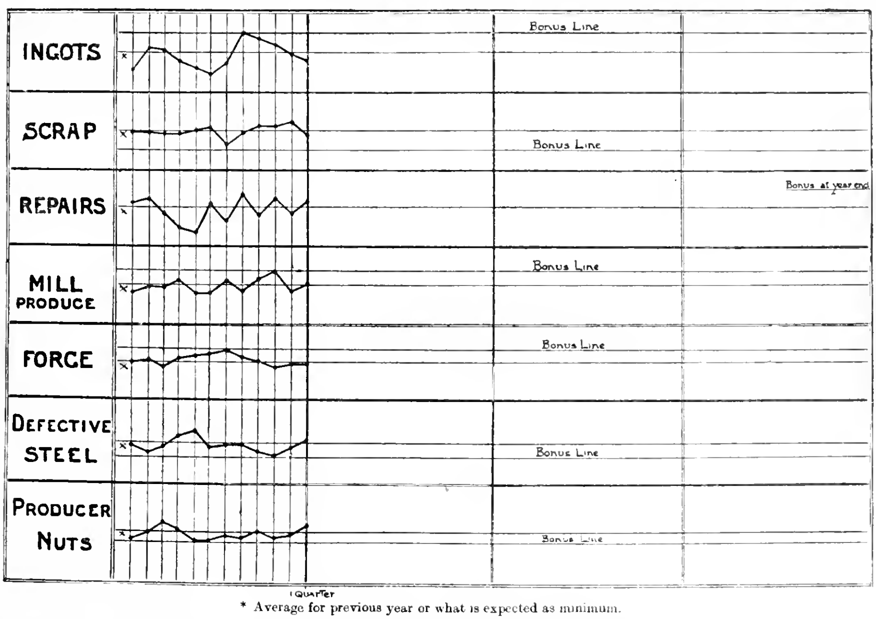
slag, which has perhaps been the main obstruction to producing sound high-grade steel. A good many of the claims of the electric basic furnace apply equally as well to basic open-hearth. The main difference in the two processes, ignoring certain mechanical advantages, is the quick supply of local intense heat in the furnace. The physical state and chemical composition of the slag in a basic open-hearth process are the main essentials for success. Giving full appreciation to the valuable work done in this country by Mr. E. H. Saniter and other eminent metallurgists, in working out the process as a formidable competitor of the acid open hearth, little has been done in establishing its position in the industry as far as special and alloy steels are concerned. The failure of the material is not due to the pro-



No. 1.—Section of Basic O.H Steel. Made for Tires. Showing unsoundness due to unsuitable conditions of slag and bath at tapping.

cess, but to incomplete exploitation or faulty manipulation.

If the basic open-hearth process is worked with highly phosphoric raw material direct, and with one slag only, it will not prove to be a serious rival of the other processes in the special steel trades. I may be told that the

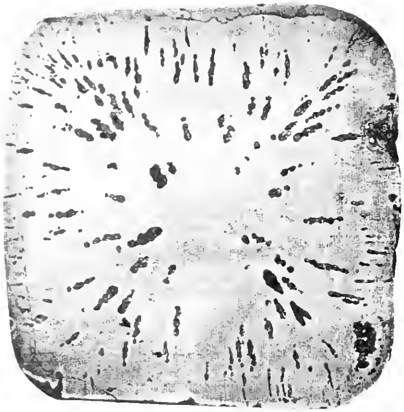



* Average for previous year or what is expected as minimum.

Fig. 13.—Yield and Cost Chart. Melting Shop. D Furnace. (January 1 to December 31, 1917.)

To bring closer relationship between melting shop, mill, and forge, and bring home defective material. Also to formulate a bonus system to increase output and quality, giving the steelmakers interest beyond the ingot.

particular advantage is in its adaptability to the use of almost any class of raw material. I maintain that the load (if I may use the term) of the working of the charge is in ratio to the phosphorus content; and that the means necessary for its removal constitute the first source of danger in the way of poor material. Charges relatively high in phosporous have to be more than liberally dosed with oxide to effect elimination of that



No. 2—Section of Electric Steel Ingot, showing (1) Blowholes wild steel, (2) Lappiness, or folds in the ingots. (3) Included unfluxed fireclay.

element, leaving behind in the steel the undesirable oxides producing the defect as shown in photograph No. 1, Plate I.

Output.—From time to time we hear a good deal about the rapidity of continental open-hearth practice as compared with our British works, and the big difference in output certainly looks formidable. One of the chief hindrances to progress in output is due to limitation of output practised by some firms. This does not compare well with the opposite aim or conduce to efficiency. We can find furnaces limited to six charges per week, the theory being that more charges would mean "hurriedly worked" and bad steel. The fact that a neighbouring firm could 'ap. say eleven casts per week with sound results should be, but is not sufficiently forcible, argument against the stand taken. Until the big difference existing in output is broken down our tonnage will not rise to that of continental works.

---

A considerable percentage of manganese will bring about a reduction of sulphur in a cupola mixture, but will also induce high shrinkage.

To make soft castings with low shrinkage manganese must be avoided.

Manganese can counteract the red-shortness caused by sulphur and greatly neutralise the effect of sulphur to harden iron mixtures. It can be used as a physic to purify liquid iron.

The best foundry irons should contain about 1 per cent of phosphorus, the presence of which imparts fluidity and reduces shrinkage.

Combined carbon, within limits the great strengthener of cast iron. Increases fluidity and liquid shrinkage and lowers melting point. Is a hardener. Closes grain and promotes density.

## WRIT IS ISSUED AGAINST GAS CO.

Hamilton.—S. F. Washington, K.C., on July 15, acting for the United Gas and Fuel Company, issued a writ against the Dominion Natural Gas Company, Limited, and Henry L. Doherty and Company. The writ, among other things, asks for an interim injunction restraining the defendant gas company from annulling its contract and from discontiuing to supply gas thereunder to the United Gas and Fuel Company, and seeks damages for the defendants "wrongfully and maliciously conspiring, with intent to injure the plaintiff, by diverting the natural gas agreed to be supplied under this said contract to the plaintiff for distribution in Hamilton, to distributng systems and plants in Brantford, Paris, Galt and other towns and villages north of the gas belt referred to in said contract, which systems and plants are owned, controlled and operated by the defendants."

---

The very serious outlook that the labour situation is beginning to assume does not seem to have affected Hamilton to such an extent as certain other cities. There has been no very serious strikes recorded so far in the city this year. The worst has probably been the moulders' strike, which has been satisfactorily settled, and though there have been other strikes, the carpenters, a few iron workers, etc., they have either been soon settled or the work proceeded with in some other way and it is to be hoped that the Industrial Disputes Investigation Act will help put an end to such a state of affairs. From this it must not be supposed that all is lovely with regard to labour. Wages seem to be going up by leaps and bounds, and certain classes of skilled labour seem impossible to obtain at any price. In some of the busiest shops machines are standing idle waiting for operators to be found for them. Toronto firms are carrying "ads" in some of the Hamilton papers, much to the disgust of Hamilton manufacturers, and the city has been pretty well combed out for skilled labour. Common labour is perhaps not quite so scarce yet. There appears to have been a more or less general increase in the rate to try and hold the men the different firms have with them at present.

---

On June 29th the Canadian Car and Foundry Co., at their Fort William yards, launched the first minesweeper under their contract with the French Government. Eleven others are included in the order and the work is said to be progressing satisfactorily. We had hoped to have been allowed to publish some details and descriptive matter, but circumstances have prevented the necessary permission from being given.

---

Combined carbon, within limits the great strengthener of cast iron. Increases fluidity and liquid shrinkage and lowers melting point. Is a hardener. Closes grain and promotes density.

---

A high phosphorus iron will generally have less tendency to absorb sulphur from the coke than a low phosphorus iron.

---

Somewhere between 30,000 and 35,000 cubic feet of air are required per ton of iron melted in a foundry cupola.

# Chemistry of the Brass Rolling Mill, or the Relation of the Chemical Laboratory to the Brass Rolling Mill

By M. B. KARR.

Metallurgist, Brown's Copper and Brass Rolling Mills, Ltd., New Toronto.

(Read before the Montreal Metallurgical Association, May 15th, 1918.)

Among the several factors that make for the success or failure of an attempt to operate a brass rolling mill in face of modern industrial conditions and competition, not the least important is the chemical laboratory.

The largest and most successful mills are those that early recognized the value of chemical analysis and control, and they are well aware of the fact that no small part of their success is due to the knowledge and control of their processes that applied chemistry and metallurgical knowledge has given them.

It is one of the commonest facts of business psychology that the average small manufacturer hesitates long before he falls in line and follows the trail his leading competitors have blazed for him. His hesitation in this particular is one of the reasons for his remaining a small manufacturer. Innate conservatism limits his horizon and makes progressive methods appear too expensive. Chemistry is expensive, so much so in fact, that when the question of establishing and operating a chemical laboratory is raised, Mr. Small Manufacturer brings out his scratch pad and proves to his own satisfaction that the few small chemical determinations he thinks he needs can be obtained at a commercial laboratory for one-half to one-quarter of what they would cost him to make. This consideration of cost, together with the fact that a similar business can be operated with a certain measure of success without direct chemical control, have operated together in the past to prevent some brass rolling mills from installing laboratories, the need of which they failed to realize.

With most mills, the start in the direction of establishing any technical control of their processes has usually been made in a small way. The original laboratory in most small mills and foundries has generally consisted of a lean-to or shed, located in some out-of-the-way corner of the shop, or else in some part of a room or hole in the wall partitioned off, equipped with some half-hearted apology for a fume hood, with a totally inadequate hot plate, a few test tubes, beakers and other miscellaneous paraphernalia that are the usual adjuncts of a high school laboratory. In the beginning of most brass laboratories, the apparatus has been totally inadequate and insufficient to cover in any way the scope of work which such a laboratory should perform. Also the idea has remained, and persists even to this day, in the minds of many manufacturers of metal goods, that the chemist himself is merely a necessary evil, to be tolerated as such and paid accordingly. In the minds of the general public, and this remark applies with particular emphasis in Canada, the idea of a chemist trained to make accurate quantitive determinations has not as yet become dissociated from the old idea of a chemist who was merely a dispensor of drugs and who masqueraded under the title of chemist, because that title seemed more impressive than the title pharmacist. As the brass manufacturers of the country have come of recent years more directly into contact with each other through the different societies, especially through the American Institute of Metals and the American Foundrymen's Association, and have come to read the trade papers devoted to their specialties, they have learned to realize the true significance of chemical control as applied to their industries, and those of them who have had small and insufficiently equipped laboratories often times manned by only partially trained men, have learned to want to obtain results in their business that their larger and more successful competitors are obtaining.

The present war has awakened the average small manufacturer of metals to the fact that he must have accurate scientific knowledge of the nature of his raw materials and finished products, and has contributed more to the widespread dissemination of technical knowledge and control of the manufacture of non-ferrous metals than any fifty years of peace in our history.

To-day, as never before in the history of the manufacture of non-ferrous metals, the actual necessity for accurate technical knowledge of the chemical composition and physical properties of raw materials and finished products is keenly realized by the manufacturer of non-ferrous products, and by none more keenly than the members of the brass rolling mill industry. Previous to the war many small mills were content to plod along following the rule of thumb methods, having no accurate knowledge of what they were buying or of what they were making. The exact standards required of metal produced for munitions changed all that almost over night. The small mills were forced to establish laboratories and install scientific methods in order to meet Government specifications. Having taken this step, they were not slow to realize the value of scientific methods as opposed to the old regime of rule of thumb, and were agreeably surprised to find that the same methods of technical control which were so essential for munition work were of equal value when applied to the manufacture of commercial rolling mill and foundry metals.

We have been forced to make a real step in advance, and having made it, we see the value of it and will not retrace our steps. The chemist, formerly considered an expensive luxury, has had an opportunity to prove his case; he has come into his own, has made good, and is here to stay. The brass rolling mill or foundry, which has installed a chemical laboratory in order to meet the specifications of metal for munitions, has wakened to a realization of the fact that exact quantitive knowledge of the chemical and physical properties of raw materials and finished products is of as great assistance in meeting commercial competition as in meeting Government specifications. By

means of detailed and accurate study, and determination of the effect of the variations of chemical analysis upon the physical properties of non-ferrous metals, many obscure points in the practical handling of brass rolling mill alloys are being elucidated. The up-to date chemical laboratory, with its equipment for chemical analysis, physical tests, experimental heat treatment and metallography, is in a position to bring applied science to bear upon the solution of the many and complex problems that constantly arise in a plant producing non-ferrous alloys.

The important position into which the chemical laboratory has come, in the larger brass mills, is indicated by the fact that the most important branches of the work of producing brass rolling mill alloys, that is to say, the casting, annealing and final inspection, are coming more and more, in the larger plants, under the direct control of the laboratory; in fact, in some of our largest and best organized mills to-day, the casting annealing and final inspection are directly controlled by the laboratory.

In presenting a detailed study of the relation of the chemical and metallurgical laboratory to the brass rolling mill, it is perhaps well to start with the tests and analyses of supplies and raw materials. The determination of the chemical and physical properties of the materials of engineering, such as steels, cement, etc., which are used in the construction, equipment and maintenance of the plant, are well within the scope of the well equipped modern laboratory.

Chemical analyses and physical tests of the various grades of lubricating and fuel oils, greases and lubricating solutions are of direct value to the purchasing department in giving it useful information by which it can be guided in the purchase of these very important supplies. The foregoing statement applies with equal force to chemical and calorific tests of the various grades of coal and oil purchased by the brass mills. Chemical, physical and metallographic tests are of special value when applied to the large number of alloy steels used for dies, tools, punches, rams, mandrels, saws, etc., that are used by the brass rolling mill.

The chemical analysis of the raw metals such as copper, spelter, nickel, tin, lead, special copper alloys, and scrap metals, which are consumed directly in the manufacture of rolling mill alloys, is, of course, of still greater importance, because of the absolute necessity of knowing just what impurities are present in these metals, and to what extent. The brass rolling mill of to-day must have an accurate quantitive knowledge of the impurities present in the raw metals which it purchases. Without this knowledge the mill is working absolutely in the dark, and the management are trusting to luck to see them through. The accurate classification of the raw materials, particularly copper, spelter, nickel and scrap metals, is one of the most vital functions of the chemical laboratory in a brass rolling mill. The amount of trouble and loss that ensue from lack of the exact knowledge of the impurities and chemical composition of these materials is so great that in this one sphere of activity alone the chemical laboratory will justify its existence, in the brass rolling mill of moderate size, were it to do nothing more than analyse these raw materials.

Having completed the analysis of the raw materials on hand the next function of the modern brass mill laboratory is to calculate the amounts of the several materials to be used in making the various alloys required each day to fill orders turned in to the casting shop. In connection with this subject, also, comes up the question of special methods of casting, and of the amounts of special alloys to be added for the purpose of giving special physical or electrical properties, to meet particular specifications. The laboratory, with its knowledge of the metallurgy and electro-chemical properties of various metals and alloys, is in a position to give definite information, or to conduct investigations, researches and experiments in the making of special alloys to meet the various requirements of specifications on which the mill is working.

During the process of casting, or at the shears, samples of the various alloys cast are taken and sent to the laboratory for chemical analysis. These analyses check the calculations previously made, demonstrating the relation between the calculated analysis and the analysis actually obtained for each alloy, thereby giving definite quantitive knowledge upon which to base future calculations, demonstrating errors in weighing of charges or mixing, and furnishing definite quantitive knowledge as to the chemical composition of metals poured in the casting shop.

The metal having been poured and analysed, the next function of the modern laboratory is to prescribe the necessary heat treatments as to time, temperature and quenching or cooling of the annealed metal for each alloy, at each gauge and after the final rolling or drawing, to produce the required temper or, if it is annealed metal, the physical properties, specified on the order. The laboratory is also in position to specify whether or not the metal must be annealed, and how this must be done, before the first, or breaking down, rolling or drawing. The necessary heat treatment of each alloy is determined experimentally by the laboratory by experimental annealing and quenching or cooling in the laboratory, and by experimental work in mill, working on standardized loads, so that each alloy or group of alloys at each pass or draw goes to the annealing muffles in loads of standard size, and is annealed in a standard manner at a standard temperature for a specified and definitely fixed time. The necessary data in order to obtain this result are acquired by collating the temperature determined experimentally for each alloy at each gauge in the laboratory with the time required to anneal the standard load to uniform temper in the type of muffle actually in use at the mill. Next to the casting, the annealing is the most important process in the manufacture of brass rolling mill alloys, and it is in the exact scientific control of the annealing that the laboratory performs one of its most important functions.

The various alloys having been rolled or drawn to the finished gauge and having gone through such processes of annealing, rolling, extruding or drawing as are necessary to produce a required size and temper, and such processes of pickling, levelling and slitting as are required to obtain the requisite surface, flatness and width required in each case, the next function of the laboratory is to pass or reject, through its inspection department, at the final inspection, all metal ready for shipment. The tendency to-day of the larger mills is to combine the inspection department with the laboratory, instead of having the inspection department directly under the production end of the mill. Unquestionably the process inspection, that is to say the inspection of the metal at various stages

during the process of its manufacture, is best performed as a function of the producing department. On account, however, of the direct connection between the various specifications which have to be met in modern brass mill work and the laboratory which has to make the tests to see whether or not these specifications are met, the tendency of recent years has been to place more control of the final inspection with the laboratory department. This is particularly true in regard to rods, for in the rod mill many of the most important orders have very exact chemical and physical specifications which must be met in order to insure acceptance of the order and satisfaction to the customer. This tendency to establish definite standards, particularly as to temper, is also becoming well established in the sheet mill work. The laboratory is, of course, the one place in the mill best qualified and equipped to perform tests upon the temper of any given metal. Visual, gauge and curvature inspection eliminates metal obviously defective in these particulars. Temper is determined in the laboratory upon representative samples of each lot prepared for shipment. In the case of hard rolled heavy metal, temper is determined by the Brinell or Scleroscope on the heavy gauges down to No. 10 B. & S., and by the Scleroscope or Erichsen machine on the thinner gauges. Annealed tempers are determined on heavy gauges, 10 gauge B. & S., and above, by the Brinell machine, and on light gauges, below No. 10 B. & S., by the Scleroscope, Erichsen or Microscope, depending upon the specifications furnished on the order. The Erichsen machine gives valuable information as to the drawing and spinning qualities of annealed light gauge metal. The microscope is generally regarded as furnishing the most reliable information as to the temper of annealed light gauge metals, showing the actual crystal or grain size which may be measured and expressed as the number of crystals to the inch or millimetre, or in terms expressing the size of crystals in thousandths of an inch or millimetre.

On all orders specifying physical tests such as yield point, tensile strength, elongation, reduction in area, compression, etc., samples are taken at the final inspection, test pieces are prepared from these, and the specified tests are made to determine whether the metal will pass the physical specifications.

The laboratory also carries on experimental work on the production of the brass mill metals. This includes all processes involved in the manufacture of special alloys to meet specifications submitted, and experiments when necessary as to the possibility of meeting unusual requirements as to composition and physical properties. The laboratory also constantly conducts experimental and research work in connection with new or improved methods of handling and manufacturing the alloys made in the mill. This work includes experimental work in the casting shop, in the rolling mill, and in annealing and pickling. The pickling of metal is also generally controlled to a certain extent by the laboratory, in that the laboratory makes tests at stated intervals of all pickle solutions used in the mill, and reports to the mill foreman or superintendent what changes, if any, are necessary in the solutions in the various tanks.

To sum up the whole subject of the relation of the modern laboratory in its greatest development to the brass rolling mill of to-day, the following statement may be made: The laboratory tests all materials of engineering supplies purchased or submitted for purchase, all fuels, lubricants and acids, or other cleaning or pickling materials, and all raw metals; it directs the mixing and casting of all alloys made, analyses all alloys made, directs and controls all heat treatments and pickling of the metals in process, carries on experimental work looking for improvement of processes and alloys, determines definitely what alloys can or cannot be successfully made with the equipment available, what specifications can or cannot be met, inspects and tests all metal ready for shipment and passes or rejects them upon the results of these inspections and tests.

## ENGINEERS MEET IN TORONTO.

A well attended meeting of the American Society of Mechanical Engineers, Ontario Section, and the Toronto Branch of the Engineering Institute of Canada, was held in the lecture room of the Engineers' Club on Wednesday evening, July 3rd. Two subjects were presented.

The first was a very interesting paper by Mr. Edward Maybee on "Patents of Invention." This covered particularly the part of the patent field of interest to engineers and a number of points which are generally not well understood were explained in a very clear and interesting way by Mr. Maybee.

The second subject was an address by Mr. Holmes of the Invalided Soldiers' Commission on "The Training of Disabled Soldiers in the Industries." The training of returned soldiers falls into three classes,—that of the hospitals, then in the re-education schools and lastly in the shops of the industries themselves. With this last department, Mr. Holmes dealt and explained the organization and methods of handling the work. It is with this industrial phase of the training that the engineers and employers should be closest in touch. It is here that they can help most.

Mr. Holmes explained how the preliminary survey is made of each plant before men are placed there, and that a careful supervision is kept over the men and their work by the Government Commission during the period of their instruction. The men receive pay from the Government and instruction from the firm. Over 90 per cent of the men so placed have made good and are now earning or making good progress towards earning a comfortable income.

The principal point brought out was that the returned men should not be dumped upon the industrial field and left to shift for themselves, but their cases must be studied individually and the men allotted to positions suiting not only the man's natural capacity but also the nature of his wounds or physical deficiency.

---

It is a common mode of expression to refer to the "loam-end" or the "sand-end" of a foundry. The foundry floor should be subdivided into sections suitable to the nature of the work to be done. By such an arrangement the "sand-end" would have two sections—viz., the "bedding-in" section and the roll-over box section. Boxes and tackle would accumulate where they were most wanted, the hard part of the floor would be definitely located, and much of the preparatory digging and ramming would be avoided.

# Crushing Strength of Magnesia-Silica Mixtures at High Temperatures

By O. L. KOWALKE[2] and O. A. HOUGEN.[3]

Magnesia, because of its high melting temperature and strong basic qualities, is one of the most important refractories for electric furnace operation. It has served for crucibles used for melting alloys at high temperatures, especially where it was desired to keep the metal or alloy free from contamination with carbon. Although magnesia melts at 2,800 deg. C.,[4] it becomes mechanically weak and somewhat plastic much below this temperature, so that when used for crucibles it must be backed up by some stronger material. At temperatures above about 1,600 deg. C. a charge of molten iron in a crucible 3 inches by 5 inches high (7.6 cm. by 12.7 cm.) will break through the magnesia, owing to its low mechanical strength.

An investigation was made by one of us to determine whether the addition of various metallic oxides, such as $Al_2O_3$, $Cr_2O_3$, $TiO_2$, $SiO_2$, $ZrO_2$, to magnesia would give a mechanical strength at high temperatures greater than magnesia itself. This preliminary investigation showed that in general there was an increase in mechanical strength. Of all the materials tried, silica gave the best results.

The purpose of this investigation was to determine more closely the influence of silica upon the crushing-strength capacities of silica-magnesia mixtures at high temperatures.

### Procedure.

A pure grade of magnesia was prepared from Merck's "Magnesium Oxydatum" by calcining the same in a gas furnace at about 1,500 deg. C. The analysis of the calcined product was: MgO 99.92, $Fe_2O_3$ 0.08, $H_2O$ 0.02. The silica used was obtained from a rather good grade of quartz, which analyzed: $SiO_2$ 97.66, CaO 0.86, $Fe_2O_3$ 0.80, $H_2O$ 0.08.

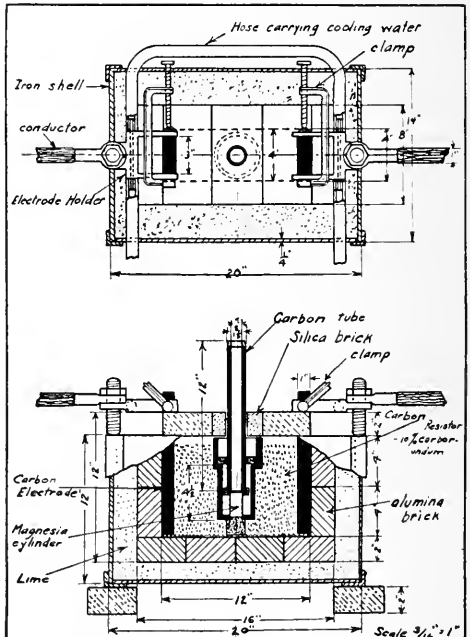
Both materials were ground to 40-mesh (16 per cm.) in a porcelain ball-mill. Afte rgrinding, the two were mixed in the various proportions desired and tumbled again in a porcelain bail-mill to insure intimate mixture. From the mixtures of silica and magnesia test cylinders were made.

The mixtures of silica and magnesia were moistened with 10 per cent (an amount found most effective) of their weights of water, and then formed into cylinders in a hydraulic press under a pressure of 1,500 lb. per sq. inch ((105 kg. per sq. cm.). They were dried at 100 deg. C., and then baked in a granular carbon resistor furnace to about 2,100 deg. C. After the cylinders had cooled in the furnace, they were ground to a uniform cylindrical form, 1 inch diameter by 2 5/32 inch long (2.54 cm. diameter by 5.5 cm. long), with the ends parallel.

The test cylinders were then put under a uniform static load of 66.5 lb. per sq. in. (4.65 kg. per sq. cm.) and heated at a uniform rate until they failed. The rise in temperature and the temperature at which failure occurred were measured by means of a Holborn-Kurlbaum optical-pyrometer.

### Apparatus.

The furnace used for testing the cylinders is shown in Plate I. The resistor consists of carbon plus ten per cent of carborundum. The magnesia-silica cylinder under test (D, Plate II) rested upon a graphite block A which was held in place by a graphite cru-




ELECTRIC FURNACE FOR TESTING CYLINDERS.

PLATE I.

cible B . The pressure was transmitted to the magnesia cylinder D through the carbon tube C and the graphite disc E. Recesses were turned in the disc E so that the test cylinder D and the carbon tube C were held in place. A cover ring of graphite F was placed on top, and another graphite tube G was fitted around the crucible B to prevent the resistor from falling in.

Pressure was applied to the carbon tube by means of a lever and weight, so arranged that eccentric loading was minimized. The lever was kept as horiontal as possible, and the motion sideways was also restricted, yet freedom of motion in a vertical plane was possible.

The Holborn-Kurlbaum optical pyrometer was mounted on a platform so that the line of sight in the telescope coincided with the axis of the carbon tube C, Plate 55. The tube C served as a "black body" for observing the temperature of the test cylinder. The brightness of the lamp filament in the pyrometer was matched against the brightness of the disc E

[2]Professor of Chemical Engineering University of Wisconsin.
[3]Instructor in Chemical Engineering, Univ. of Wisconsin.
[4]Kanolt: Bull, Bureau Standards, 10, 295.

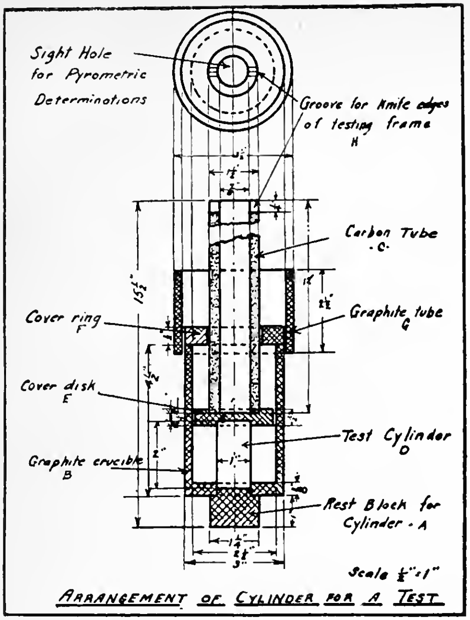



Plate II.

which was ¼ inch (6.5 mm.) thick at the section covering the test cylinder. All carbon and gaphite parts used in the temperature measurements were first thoroughly heated to above 2,100 deg. C. to distill off any volatile materials or such as would produce fume. Since the rise in temperature of the furnace was very slow, it was assumed that observations for temperature on the graphite disc would also give the temperature of the test cylinder. The pyrometer was provided with a rotating sectored disc to permit extension of the range without overheating the lamp, and it was calibrated platinum thermo-couple according to the method proposed by Prof. C. E. Mendenhall.[6]

**Preliminary Tests.**

After a few tests had been made it was recognized that the rate of heating the cylinders under test had a big influence on the result. The preliminary tests were made in the apparatus just described, but the cylinders were heated rapidly to 1,000 deg. C. and then beyond that to the point of failure at rates varying from 10 deg. to 20 deg. C. per minute. But it soon was clear that the rate of heating below 1,000 deg. C. affected the results obtained. All temperatures were measured by the optical pyrometer, and since this is not sensitive below 800 deg. C., the results were not satisfactory. The following table shows the irregularity of the results from this procedure.

**Crushing Temperature of $MgO/SiO_2$ Mixtures Under Load.**

| Percent silica. | Tempt. of Failure. | Rate of Heating deg.\|min. | Temp. of Failure. | Rate of Heating deg.\|min. |
|---|---|---|---|---|
| 0 | 1,682 | 19 | 1,684 | 10 |
| 3 | 1,752 | 16 | ..... | .. |
| 5 | 2,708 | 15 | ..... | .. |
| 7 | 1,756 | 22 | 1,924 | 8 |
| 9 | 1,736 | 20 | 1,902 | 12 |
| 11 | ..... | .. | 1,800 | 13 |

[6]Mendenhall and Forsythe: Phys. Rev., 1911, 33, 74.

The manner in which the test specimens failed was quite uniform; it usually occurred by the cylinders bursting out at the middle, with ends telescoping each other.

While the rate of heating affected the results obtained on the magnesia-silica cylinders, it did not affect the results in a similar manner when pure magnesia cylinders were tested. A change in the rate of heating pure magnesia had but little effect on the temperature at which failure occurred. Failure in the magnesia cylinders came on gradually and slowly; in the magnesia-silica cylinders the failure was always abrupt.

**Final Tests.**

From the preliminary tests it was evident that the addition of six to eight per cent silica to magnesia gave a product whose strength at high temperatures was greater than pure magnesia. Owing to irregularity in the baking and testing, the results were open to question. A series of cylinders having amounts of silica varying from zero to twelve per cent was made and baked at the same temperature—about 2,100 deg. C. In the load-carrying tests, the temperature for each specimen was raised at a uniform rate of 10 deg. C. per minute, from room temperature to the point of failure. A thermo-couple was used to measure temperatures below 1,000 deg. C., and the optical pyrometer above that point.

The results of these tests are given in the table below. It is apparent that there is a distinct maximum at about seven to eight percent silica. The increase of strength up to eight percent silica is somewhat more rapid than the decrease in strength beyond that amount. The specimens having 7½ per cent silica failed at a temperature 190 deg. C. higher than that for pure magnesia.

| Silica Content per cent | Temperature at Failure |
|---|---|
| 0 | 1,680 deg. C. |
| 3 | 1,800 |
| 6 | 1,850 |
| 7 | 1,860 |
| 7½ | 1,870 |
| 8 | 1,845 |
| 8 | 1,860 |
| 12 | 1,830 |
| 12 | 1,845 |

Heat treatment during baking was recognized as an important factor in determining the subsequent strength of the cylinders. A series of cylinders containing 7.5 per cent silica was made in the regular manner. The temperature of each cylinder in baking was raised uniformly at the rate of 20 deg. per minute from room temperature to the maximum, and then the maximum was maintained for an hour. Then cooling proceeded slowly in the furnace. Cylinders so treated were baked respectively at 1,500 deg. 1,800, 1,950, and 2,200 deg. C. The cylinders heated to 1,950 deg. C. and 2,200 deg. C. were badly pitted and corroded and showed a low temperature of failure.

| Temperature of Baking | Temperature at Failure Under Load |
|---|---|
| 1,500 deg. C. | 1,570 Deg. C. |
| 1,800 | 1,820 |
| 1,950 | 1,720 |
| 2,200 | 1,790 |

The corrosion and pitting noted in the above tests above 1,900 deg. C. made it desirable to study the effect of prolonged heating on the loss in weight. A series of cylinders having approximately 7.3 per cent of silica were baked at various temperatures for varying lengths of time and allowed to cool in the furnace. Each cylinder was weighed before and after baking to determine the loss. The results are given in the following table:—

| Maximum Temperature of Baking | Per cent Loss in Weight. | Heat Treatment. |
|---|---|---|
| 1,500 deg. C. | 3.7 | 1 hour at maximum temp. |
| 1,800 | 6.1 | 10 min. at maximum temp. |
| 1,800 | 7.4 | 1 hour at maximum temp. |
| 1,800 | 8.5 | 10 min. at maximum temp. |
| 1,850 | 7.5 | 10 min. at maximum temp. |
| 1,900 | 9.8 | 10 min. at maximum temp. |
| 2,000 | 14.6 | 1 hour at 1,950 deg. C. |
| 2,000 | 17.1 | 1½ hours above 1,950 deg. C. |
| 2,000 | 11.0 | 1 hour at E,950 deg. C. |
| 2,100 | 31.7 | 1½ hours at maximum temp. |
| 2,200 | 27.0 | 1 hour at maximum temp. |

From this data it will be seen that prolonged heating above 1,900 deg. C. produces a great loss in weight, and that for temperatures above 2,000 deg. C. the loss increases rapidly. In one case of prolonged heating at 2,100 deg. C. complete volatilization of a magnesia-silica mixture resulted, due to the violent action of carbon upon both magnesia and silica. Cylinders baked at 2,100 deg. C. and suddenly quenched in cold water produced a distinct acetylene odor.

Since the above heat treatment proved to be too severe, another set of 7½ per cent silica cylinders was baked under less severe treatment. In this baking all cylinders to be heated at 1,800 deg. or above were maintained at 1,800 deg. C. for one hour and then heated at the usual rate, 20 deg. per minute, until the maximum temperature was reached. Data obtained is given herewith.

| Maximum Temperature of Baking | Crushing Temperature. |
|---|---|
| 1,500 deg. C. | 1,570 deg. C. |
| 1,800 | 1,820 |
| 1,850 | 1,870 |
| 2,100 | 1,900 |

This data shows that increased temperature and duration of baking increases the subsequent strength of the cylinders, but prolonged heating above 1,900 deg. C. must be avoided, because of the destructive action of carbon upon magnesia.

### Microscopic Examination.

Thin sections of various cylinders, baked at various temperatures and cooled in various ways, were made, to permit a microscopic examination of the crystallographic structures produced.

The specimens from which the thin sections were taken were all made with 7.5 per cent silica. As shown in the table below some were heated to a predetermined maximum temperature, held there for a given period of time, and then quenched in cold water; other cylinders were allowed to cool slowly in the furnace after being brought to the maximum temperatures.

| Mark. | Maximum Temp. of Baking ° C. | Rate of Heating per Min. | Period of Heating at Max. Temp. | Cooling. |
|---|---|---|---|---|
| A | 1,800 | 20° | 10 min. | Quenched in cold water |
| B | 1,850 | " | 10 min. | " " " |
| C | 1,900 | " | 10 min. | " " " |
| D | 1,950 | " | 10 min. | " " " |
| E | 2,000 | " | 1 hr. at 1,950° C. | " " " |
| F | 2,000 | " | 1½ hrs. above 1,950° C. | " " " |
| a | 1,800 | " | 10 min. | Cooled slowly in furnace. |
| b | 1,850 | " | 10 min. | " " " |
| c | 1,950 | " | 10 min. | " " " |
| d | 1,950 | " | 10 min. | " " " |
| e | 2,000 | " | 1 hr. at 1,950° C. | " " " |
| f | 2,100 | " | 1½ hrs. above 1,950° C. | " " " |
| g | 1,500 | " | 1 hr. | " " " |
| h | 1,800 | " | 1 hr. | " " " |
| i | 1,960 | " | 1 hr. | " " " |
| j | 2,200 | " | 1 hr. | " " " |
| k | 2,120 | 40° | (Pure magnesia) | " " " |

In these specimens the minerals Periclase and Forsterite were identified. Below 1,500 deg. C. there is only a slight formation of Forsterite. This mineral is formed first in minute crystals in the grain boundaries of Periclase. As the temperature is raised to between 1,700 deg. C. and 1,800 deg. C. the crystals grow rapidly in number and size, and finally unite to form a complete envelope about the Periclase. Above 2,000 deg. C. this envelope of Forsterite, due to surface tension, collects into separate crystals. Specimens in which the Forsterite had collected into separate crystals failed under load at a lower temperature than those specimens where the envelope remained intact. This would appear to show that the Forsterite acts as a binder to hold the Periclase together, and that failure comes at a temperature when Forsterite softens.

The Microphotographs shown in Plates III and IV were made with polarized light and crossed Nicols. The Periclase is represented by the black areas and the Forsterite by the white; the magnification being about 40 diameters. From Plate IV it is apparent that the Forsterite growth is progressive with a rise in temperature. The quenching operation serves to repress the formation of Forsterite, as shown in Plate III.

Pure magnesia, whose melting point is 2,800 deg. C., has the proberty of bonding itself at temperatures 1,000 degrees below its melting point, into a hard mass. As shown in Plate V., made in unpolarized light, the grain boundaries are fairly distinct. This specimen was thicker than the ordinary run of thin rock sections, but the material did not permit of thinner grinding without breaking. This specimen was baked at 2,100 deg. C.; no other specimens of magnesia baked at lower temperatures were examined microscopically.

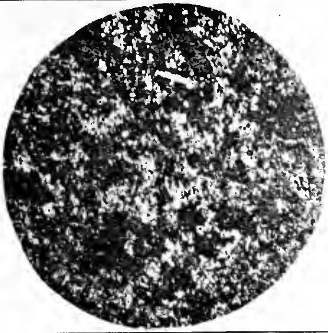


Fig. 1. c—baked at 1,900° C.; cooled in furnace.

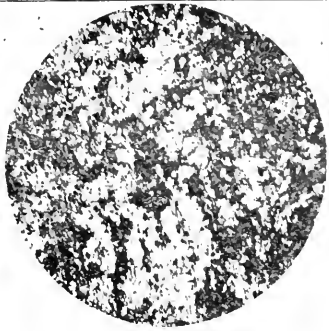


Fig. 2. e—baked at 2,000° C.; held 1 hour above 1,950° C.; cooled in furnace.

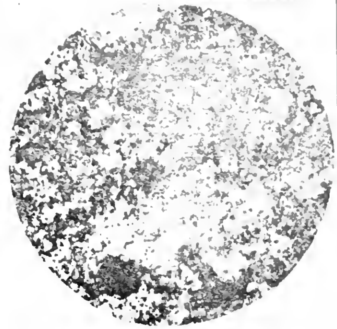


Fig. 3 f—baked at 2,100° C.; held 1½ hours above 1,950° C.; cooled in furnace.

Plate III.

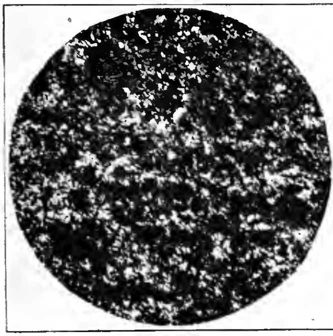


Fig. 4. A—baked at 1,800° C.; quenched in cold water.

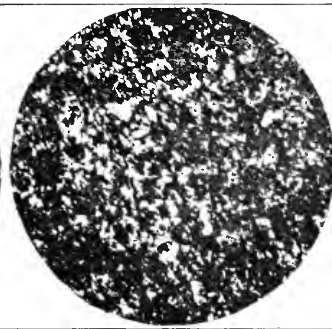


Fig. 5. E—baked at 2,000° C., held 1 hour above 1,950° C., quenched in cold water.

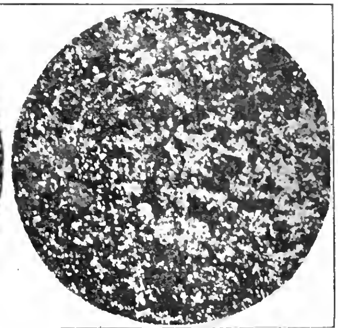


Fig. 6. F—baked at 2,000° C. held 1½ hours above 1,950° C.; quenched in cold water.

Plate III.

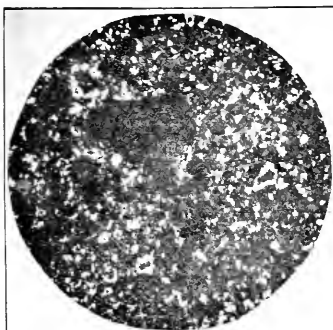


Fig. 7. g—baked at 1,500° C. for 1 hour.

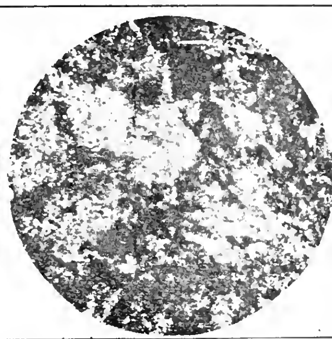


Fig. 8 h—baked at 1,800° C for 1 hour.

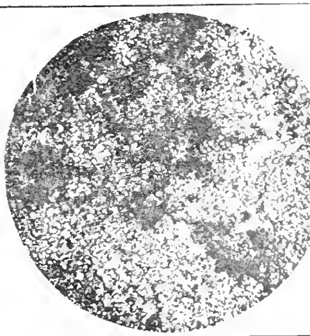


Fig. 9. i—baked at 1,960 C for 1 hour.

Plate IV.

**Acknowledgment.**

Grateful acknowledgment is here made to Professors A. N. Winchell and W. J. Mead, of the Department of Geology of the University of Wisconsin, for many suggestions and assistance in identifying the minerals the use of equipment, and the making of the microphotographs.

**Conclusions.**

1. Pure magnesia failed under a load of 66.5 lb. per sq. in. (4.65 kg. per sq. cm.) at a temperature of 1,680 deg. C.

2. The addition of silica to magnesia, with seven to eight per cent silica as a maximum, increased the me-

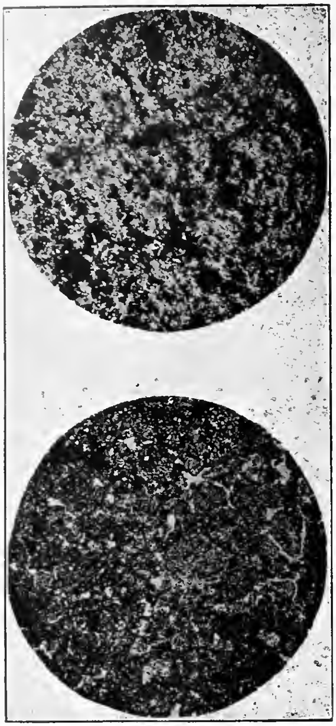


Plate V.

Fig. 10. j—baked at 2,200° C. for 1 hour.
Fig. 11. Pure Magnesia—baked at 2,120°C.
(40 Diameters—Unpolarized light.)

chanical load-carrying capacity, so that failure occurred only at about 1,870 deg. C., which is approximately 190 degrees higher than magnesia supported.

3. The failure of magnesia cylinders is slow and gradual; that of magnesia-silica cylinders is abrupt.

4. The superiority of magnesia-silica mixtures with 7½ per cent silica, over pure magnesia, in mechanical load-carrying capacity, appears to be due to the envelope of Forsterite, which cements the grains of Periclase.

5. Above 2,000 deg. C. carbon attacks magnesia-silica mixtures very rapidly.

—Chemical Engineering Laboratories, University of Wisconsin.

NOTE.—This paper was read before the Electro-Chemical Society, May 1918.—Ed.

## HAMILTON.

We are informed that the Dominion Foundries and Steel Co., Ltd., has acquired the undertakings of Dominion Steel Foundry Company, Limited, and Hamilton Steel Wheel Company, Limited, and will under the same board of directors and management continue the business as heretofore.

# The Determination of Cobalt and Nickel in Cobalt Steel

By W. R. SCHOELLER, Ph.D., and A. R. POWELL
(London.)

This paper is the second on the subject of a rapid process for determining cobalt and nickel in ores and alloys. The first communication was published in the Analyst (1917, vol. xlii. p. 189). The reaction on which our process is based consists in the precipitation of hexammine cobaltous and hexammine nickelous iodides by means of potassium iodide in strongly ammoniacal solution, the precipitation of the trivalent metals by the ammonia being prevented by the addition of tartaric acid. Iron, which in the usual methods of assay is removed by precipitation and causes trouble by occluding some of the cobalt and nickel, is thus removed in a soluble form.

In applying this procedure to cobalt steel, it was at once found that the large amount of tartaric acid required to keep up the iron and chromium (10 grammes for 1 gramme of steel) retarded the complete precipitation of the cobalt sufficiently to render the process useless. An attempt was therefore made to remove the bulk of the iron by precipitation, and then complete the separation by the iodide process. Such a manipulation would still be preferable to the removal of the iron by one of the usual methods (e.g. as basic acetate).

The elimination of the bulk of the iron was satisfactorily accomplished by means of sodium carbonate, using thiocyanate as an external indicator. The filtrate was then evaporated to dryness with nitric acid, taken up with 2 to 3 grammes of tartaric acid, made strongly ammoniacal, and precipitated with potassium iodide (Method I.).

The process now proved much more satisfactory than in its original form, and the figures obtained were mostly in close agreement; yet, on continuous testing, the results were rather erratic, the iodide precipitate sometimes crystallising out slowly instead of forming instantaneously on adding the potassium iodide. After much investigation we came to the conclusion that cobalt is precipitated less readily from tartrate solutions than nickel; if the latter is present in sufficient proportion, it induces more rapid precipitation of the cobalt; if not, a minimum concentration of tartrates should be aimed at, and this in turn would depend on the quantity of trivalent metals, the precipitation of which must be prevented. Now the addition of 2 to 3 grammes of tartaric acid in the above procedure was necessitated by the presence of chromium. The latter is precipitated by sodium carbonate only after the whole of the iron has been thrown down, and to attempt its removal at this stage would involve the risk of precipitating some of the cobalt, as no convenient spot test is available for detecting soluble chromium salts in a solution containing a highly coloured iron compound.

The method was therefore further modified by eliminating the bulk of the chromium in the following manner. The filtrate from the iron precipitate was precipitated, hot, with caustic soda and bromine. The precipitate consisting of the higher oxides of cobalt, nickel, and manganese, together with a little ferric hydroxide and a trace of chromium, was filtered from the solution containing sodium chromate, dissolved in

hydrochloric acid, the solution evaporated to dryness, the residue taken up with a little tartaric acid, and precipitated with ammonia and iodide (Method II.). As soon as this mode of working was adopted, the results became concordant.

The procedure in its improved form would seem somewhat complicated, but Method II. is actually shorter than Method I. in that it obviates the evaporation to dryness of the filtrate from the iron precipitate. It is considerably quicker than the basic acetate process, apart from the fact that the latter is ineffectual in presence of much chromium. For the further treatment of the iodide precipitate, several methods may be used. After dissolving the precipitate in hydrochloric acid, the cobalt may be thrown down by nitroso-beta-naphthol, or the nickel by dimethylglyoxime. In this investigation the authors have made use of their previously published method for the separate volumetric estimation of cobalt and nickel.* Full directions for carrying out the process will be given below. As regards the time required for the determination, several assays can be completed in about three to four hours from the time the steel has been obtained in solution. The attack is usually rather protracted, several hours' boiling with aqua regia being required.

The material used in this investigation was kindly supplied by Mr. C. O. Bannister, to whom the results given in the table were submitted. Mr. Bannister is satisfied that these figures closely check those obtained by him by analysis. Sample H was assayed according to Method I., and the supply of material was exhausted before Method II. was adopted. The latter was used on samples I to K.

| Experiment. | Sample. | Cobalt per cent. | Nickel per cent. | Cobalt + Nickel per cent. |
|---|---|---|---|---|
| 106d | H | 3.51 | 0.68 | 4.19 |
| 108e | | 3.54 | 0.63 | 4.17 |
| 108g | | 3.58 | 0.65 | 4.23 |
| 116a | I | 3.21 | 0.55 | 3.76 |
| 116b | | 3.19 | 0.55 | 3.74 |
| 118a | | 3.27 | 0.41 | 3.68 |
| 119a | J | 3.85 | 0.57 | 4.42 |
| 119b | | 3.87 | 0.57 | 4.44 |
| 122a | | 3.84 | 0.55 | 4.39 |
| 123a | K | 3.62 | 0.62 | 4.24 |
| 124a | | 3.64 | 0.55 | 4.19 |
| 124b | | 3.67 | 0.55 | 4.22 |

Description of the Method.—Two grammes of drillings are weighed into a flask and treated with 30 c.c. each of strong hydrochloric and nitric acids. The assay is heated gradually at first, then boiled gently for four to six hours, and evaporated substantially to dryness over a free flame; 2 c.c. of sulphuric acid (1: 1), a little hydrochloric acid, and 25 c.c. of water are added, and solution brought about by warming. The addition of the prescribed amount of sulphuric acid is essential for the success of the next operation, as it produces a pale brown pulverulent iron precipitate which is easily filtered off.

The cooled solution is diluted to 50 c.c and precipitated with 20 per cent sodium carbonate solution added from a burette. When the iron begins to come down, a drop is withdrawn between the additions of carbonate and brought in contact with a drop of 10% thiocyanate solution in a flat porcelain dish used as a spot plate. When the red coloration grows faint and becomes masked by the rust-brown precipitate, the spot tests are returned to the assay and the latter transferred to a graduated 200 c.c. flask. The volume is made up, the solution filtered through a pleated 12.5 cm. filter, and 100 c.c. pipetted into a 300 c.c. beaker. The liquor is brought to a boil with 1 to 2 c.c. of nitric acid and treated with 25 c.c. of bromine water and an excess of freshly made caustic soda. After boiling for a minute or so, the black precipitate is filtered off on loose paper (Whatman, No. 4, 9 cm.) and washed with boiling water. It contains all the cobalt and nickel, together with small quantities of iron, chromium, and manganese, and its subsequent treatment does not differ from that previously published, except that a colorimetric manganese determination is necessary in the titrated cobalt solution. The whole procedure, partly quoted from our two papers already referred to, is hereunder described in extenso.

The precipitate is rinsed back into the beaker, dissolved in a little hydrochloric acid poured over the filter, the solution transferred to a flask, and evaporated almost to dryness over a free flame. It is again evaporated with 2 c.c. of strong nitric acid to destroy the bulk of the chlorides. A cold saturated solution of 1 gramme tartaric acid is now added, then 50 to 60 c.c. of strong ammonia (0.88 sp. gravity), followed immediately by a cold saturated solution of 4 grammes potassium iodide. A pale pink crystalline precipitate is at once thrown down. After settling for fifteen minutes, it is filtered off on a loose 9 cm. filter, and washed with ammoniacal iodide solution (strong ammonica 200, water 50 c.c., potassium iodide 10 grammes) from a wash-bottle fitted with a Bunsen valve.

The iodide precipitate (containing only cobalt and nickel with a little manganese) is dissolved in 10 c.c. of hydrochloric acid (1: 1) and a little sodium sulphite poured through the filter into a 300 c.c. beaker; the washing is done with hot water. 5 c.c. of 25 per cent ammonium phosphate solution[1] are added, the liquor heated to boiling, and treated with ammonia (1: 1), added finally drop by drop with continual stirring, until the blue amorphous precipitate first produced becomes pink and crystalline. An excess of 5 drops of ammonia is then added and the assay left to stand on a steam bath for ten minutes; on account of the small quantity of nickel present, a reprecipitation is unnecessary.

Cobalt Titration.—The pink precipitate of cobalt ammonium phosphate is filtered on a loose 9 cm. paper and well washed with hot water. The filter is spread against the side of the beaker, rinsed down with water followed by a few drops of the N-5 acid used in the titration and again with water to displace the acid, taking care not to use more than about 30 c.c. in all. The filter is now discarded, and the gradual addition of acid continued until the precipitate disappears. No indicator is requred, for the precipitate imparts a lilac colour to the liquid, while its final

*Analyst, 1916, vol. xli, p. 124.

[1]The salt is dissolved in hot water tinted with methylorange, and hydrochloric acid added till the colour turns pink. Boil five minutes, cool, and filter into stock bottle.

disappearance can be ascertained within 0.1 c.c. In order to determine the manganese (which is precipitated with the cobalt as manganese ammonium phosphate) the above titration must be carried out with N-5 sulphuric or nitric, but not hydrochloric, acid. The titrated liquid is filtered (to free it from filter fibres) into a 100 c.c. graduated flask. 10 or 20 c.c. are pipetted off, boiled with persulphate and silver nitrate in the usual manner, and the colour matched against that of a standard solution containing 0.072 gramme of potassium permanganate per 500 c.c. (1 c.c. = 0.05 milligramme manganese); 1 to 3 milligrammes of manganese are thus found. The acid consumed by the manganese ammonium phosphate (0.18 c.c. per milligramme of manganese) is substracted from the volume found, the difference giving the cobalt (1 c.c. of N-5 acid = 0.0059 gramme of cobalt).

Nickel Titration.—The filtrate from the cobalt ammonium phosphate is cooled and titrated with a solution containing 10 grammes of sodium cyanide, 2 grammes of caustic soda, and 1 gramme of silver nitrate per litre. The quantity of nickel being very small, the assay is left to stand for a few minutes after about 1 c.c. of cyanide solution has been added, when the cloudiness due to silver iodide becomes visible. The addition of cyanide is then continued drop by by drop, whilst shaking, until the liquid clears. The cyanide solution is standardised every week against pure nickel or silver.

(This paper was read at the May, 1918, meeting of the Iron & Steel Institute (England).

# Economic Uses of Silica and its Occurrence in Eastern Canada

By L. HEBER COLE.

Too little attention has been devoted to the study and exploitation of our non-metallic mineral resources by the mining fraternity; such non-metallic deposits as are at present being operated in nearly all cases are in charge of men who have little knowledge of mining methods. In consequence, the production of high-class material has been greatly hampered by mismanagement, and the percentage of failures has been large. Of course, there are notable exceptions, as some deposits are being capably handled. In the main, however, the non-metallic minerals have not been utilised to the fullest advantage, and the resultant shortage has had to be made up by importation.

The fact that nearly all non-metallic minerals bring comparatively low prices, has militated against the industry. Capital has naturally gravitated to the mining of metals with which the average layman is more or less familiar. To him the non-metallic minerals are so much rock or earth. The mining engineer is seldom called upon to report on non-metallic deposits, or to undertake their development. The fault is not confined to the investor or operator, for the mining engineer himself usually is not sufficiently conversant with the mode of occurrence of these materials, or the requirements of the several industries, to intelligently advise intending investors. To work a deposit of low-priced material economically, a large tonnage has to be produced, and this must be prepared for the market and properly graded according to the several uses for which it is to be employed.

The time has come when it behooves us to devote more attention to our non-metallic resources, and to determine their suitability to the several industries. In this paper only one of these non-metallics, namely, Silica, will be dealt with, and the few notes on its uses and occurrence in Canada are submitted in the hope that greater interest may be awakened, and that the requirements of the manufacturers who use this mineral in their various industrial processes may be better understood.

### Silica.

It is estimated that silica, as quartz, or in chemical combination, constitutes about 58.3 per cent of the earth's crust. In the form quartz it is the commonest and most widely distributed mineral. When pure, it consists of silicon 46.6 per cent, oxygen, 53.4 per cent; and is represented by the formula $SiO_2$. It crystallizes generally in the hexagonal system, the prisms terminated by rhombohedrons. The pure material is usually colourless or white, has a vitreous or greasy lustre, with hardness of 7, and specific gravity of 2.65.

Silica, sufficiently pure for industrial purposes, may be obtained in the following modes of occurrence:—

(a) Quartz crystals;
(b) Vein quartz;
(c) Quartzite;
(d) Sandstone;
(e) Natural Sand;
(f))Flint nodules;
(g) Diatomaceous Earth.

The use made of silica in many important industries is varied, and each industry requires the material to be in a certain form. Any one of the above forms of silica may be more suitable for certain uses than other forms. The selection of the special form of silica used will also depend a great deal on the local conditions, such as availability, transportation facilities, etc. The more important uses and the requirements of the several industries, will be enumerated before discussing ways and means of winning and preparing the material for the market.

### Uses of Silica in Commerce.

Silica has been employed in a number of manufacturing industries for many years. The reasons, however, why a certain sand, etc., is suitable or unsuitable for a special purpose, have rarely been systematically studied. The fact that Canada has been able to obtain extremely pure and uniform material from abroad has not tended to promote vigorous investigation of our own resources. As a result, now that the foreign supply has been greatly reduced or completely cut off, the consuming industries have been much hampered. When Canadian manufacturers learned that they would eventually have to depend on Canadian material for their supplies of silica, and commenced to investigate local possibilities, it was found that very little was known about the material obtained from Canadian deposits of silica, or of the behaviour of the mineral in the several industries.

An investigation of this nature necessitates, not only a knowledge of the mode of occurrence of silica and its properties, but also of the manner in which it is to be employed in each industry, the suitability of the various forms of silica for the various uses may be ascertained.

The following notes were made during the last two years, in the course of an investigation of the sands, sandstones, and quartzites of Canada, conduct-

ed under the auspices of the Mines Branch of the Department of Mines, Ottawa. The investigation is still in progress, and therefore the data here given must be considered as only preliminary.

### Silica for use in the glass industry.

The glass industry is one of the chief consumers of silica, using it in the form of sand. It rarely pays to crush vein quartz or quartzite for glass manufacture, hence the greater part of the material used is obtained from natural sand deposits, or by crushing a friable or loosely bonded sandstone. A silica sand answering the following requirements is demanded:

### Texture.

While there is considerable latitude allowable in the size of grains in a good glass sand, uniformity is desirable. If the grains are very large the silica combines with the other glass ingredients too slowly; on the other hand, if the sand contains much fine dusty material, there will be a considerable loss in charging, and the fine sand will carry an excess of air into the molten mass in the furnace, and an excessive heat will be required to eliminate it.

Therefore, a general specification for the texture of a glass sand would be that all the material shall pass a 10-mesh screen, and 90 per cent be retained on a 100 mesh, with 65 per cent lying between 20 mesh and 65 mesh. The following granulometric analyses of sands being used successfully in Canada and the United States are typical.

| Retained on— Mesh. | P.c. 1 | P.c. 2 | P.c. 3 | P.c. 4 | P.c. 5 |
|---|---|---|---|---|---|
| 10 | ..... | ..... | ..... | ..... | ..... |
| 14 | ..... | ..... | ..... | ..... | .42 |
| 20 | .16 | ..... | .15 | .07 | .78 |
| 28 | .94 | ..... | .15 | 1.59 | 2.18 |
| 35 | 43.44 | .15 | 50.94 | 13.11 | 7.28 |
| 48 | 39.37 | 59.69 | 28.29 | 61.71 | 30.75 |
| 65 | 10.62 | 19.23 | 10.00 | 20.25 | 37.06 |
| 100 | 4.69 | 17.81 | 7.81 | 2.79 | 19.93 |
| 150 | .63 | 2.81 | 2.19 | .16 | .85 |
| 200 | .15 | .15 | .31 | .03 | .10 |
| Through 200 | ..... | .16 | .16 | .01 | .03 |

1. Belgian Sand.
2. American Sand (Rockwood Brand.)
3. American Sand (National Brand).
4. American Sand Pittsburgh Plate Glass Co., Kennerdell, Pennsylvania (Trans. Am. Ceramic Soc. Vol. XIX., p. 181).
5. American Sand, American Window Glass Co.:—Derry, Pennsylvania (Trans. Am. Ceramic Soc. Vol. XIX., p. 181).

### Purity.

The sand should run as high in silica ($SiO_2$) as possible. Objectionable impurities are iron, alumina, magnesia, lime, and alkalies. For the best varieties of glass, viz., optical glass, flint glass, and the whitest sheet glass, the sand should contain less than 0.05 per cent iron oxide ($Fe_2O_3$), and not more than 0.05 per cent of other impurities, such as alumina, lime, or alkalies. Sands containing such a small amount of iron, rarely contain other impurities (except alumina) in measurable quantities.

Sands containing from 0.2 to 0.3 per cent iron oixde, cannot be used for the better grades of flint glass; and those containing over 2.0 per cent iron oxide would be worthless even for the manufacture of the cheapest class of bottles. The iron, when present in small amounts, imparts to the glass a pale green colour, which increases in intensity as the percentage of iron increase.* When the iron oxide content is not above 0.2 per cent, the green colour can be neutralized by a decolourizer, such as manganese, selenium, or nickel. Above 0.2 per cent iron oxide, the green colour is too intense to be destroyed.

*The iron content in the batch is not all due to the presence of iron in the sand, since nearly all the other materials used in the mixture contain iron as an impurity.

The presence of alumina in a sand, while desirable for some purposes, unfortunately tends to decrease the transparency, and also makes the batch harder to melt.

Sands containing lime are to be avoided, since the calcareous material is often sporadic in its distribution, and unless daily analyses of the sand employed are made, the lime content in the batch cannot be depended upon. It is preferable to use a lime-free sand, and add raw limestone to the batch when a lime-soda glass is being manufactured.

The following analyses are of typical high grade glass-sands:

| | 1 P.c. | 2 P.c. | 3 P.c. | 4 P.c. | 5 P.c. |
|---|---|---|---|---|---|
| Silica ($SiO_2$) | 99.12 | 99.20 | 99.58 | 99.23 | 99.80 |
| Iron Oxide ($Fe_2O_3$) | .07 | .17 | .02 | .04 | .006 |
| Alumina ($Al_2O_3$) | .43 | .53 | .12 | .59 | .13 |
| Lime (CaO) | .34 | trace | .13 | .11 | trace |
| Magnesia (MgO) | .11 | trace | trace | .02 | ..... |
| Alkalies | ..... | .10 | ..... | ..... | ..... |
| Loss on ignition | .22 | ..... | .17 | .25 | .18 |

1. Belgian Sand. (Dominion Glass Co., Montreal).
2. St. Paul, Minn. (Dom. Glass Co., Redcliffe, Alta.)
3. Wedron Silica Co., Ottawa, Ill. (British Sand Resources by Boswell).
4. "Lynn" Sand, England (Sands suitable for glass making by Boswell).
5. Fontainebleau Sand—France (sands suitable for glass making, by Boswell).

### Moisture.

Sand is capable of carrying considerable moisture, and all sand should be dried thoroughly either at the quarry or at the glass plant. The presence of moisture in a sand lessens the available amount of silica for a given weight: it should not exceed 2.5 per cent.

Therefore it will be seen that, a sand for glass manufacture should be one of uniform grain and of medium fineness—running as high in silica as possible—at least 98 per cent $SiO_2$ for bottle glass, and 99.5 per cent for the better grade of flint and window glass; be practically free from iron and other impurities; be washed to remove organic matter, etc.; and dried.

### Silica in the Manufacture of Silica Brick.

The advent of silica brick into the domain of metallurgical and industrial engineering, greatly extended the scope of the several processes and in many cases proved to be a decided advantage over other refractory materials.

Two kinds of siliceous brick are used, one having lime as the bonding material, and the other clay.

The former class, with a lime bond, is made from a pure quartzite crushed to about 8-mesh size and

thoroughly mixed in a pan with milk of lime. The milling process should be supervised carefully, since it is very important that each particle of quartzite be coated thoroughly with the milk of lime. When a slightly cohesive mass is obtained, bricks are moulded from it by hand, then partially dried, after which they are pressed by machinery, and burned at a high temperature.

The second class of acid refractories, referred to above, have a clay bond. The clay may be present either in the original rock, as is found in some of the hard sandstones of the coal measures in England, or, may be prepared by grinding a pure quartzite with a plastic fire clay; such a brick, when burned is known as "Gannister brick."

The chemical requirements for a siliceous material suitable for use in the brick industry will vary; the silica content should be as high as possible. A reliable chemical analysis is therefore of very great importance, since the refractoriness of the finished brick will depend on the silica content, and on the lack of such impurities as lime, alkalies, and iron, which tend to act as fluxes and to lower the melting point of the bricks. For example, the material used in the Pennsylvania district is a quartzite, loose boulders and fragmentary pieces of which have been torn from the parent ledges and scattered over the surrounding country. An analysis of these pieces is approximately, as follows:—

| | P.c. |
|---|---|
| $SiO_2$ | 98.00 |
| $Al_2O_3$ | 0.60 |
| $Fe_2O_3$ | 0.70 |
| CaO | 0.20 |
| MgO | 0.10 |
| Alkalies | 0.40 |

The physical properties of the silica are of as much importance as the chemical composition It has been found in testing a number of silica samples in the laboratories of the Mines Branch, that quartzites are preferable to sandstones or vein quartz, and that loose sand or gravel is altogether unsuitable, even though the chemical analysis of the latter is satisfactory. The brick manufacturers are, consequently, restricted in the selection of their raw material. Only by actual testing of a sample can it be determined whether a material is suitable for the manufacture of a silica refractory.

A suitable quartzite should, when ground, have grains which appear splintery, sharp, heterogeneous in form and size, and be slightly translucent. It should analyze, approximately, 97.5 per cent $SiO_2$; 1 to 1½ per cent $Al_2O_3$; and 0.75 per cent other impurities; when moulded into bricks and fired, it should expand and swell without perceptible cracking. The total fluxing materials in a silica brick should not exceed 3 per cent. In a gannister brick, the clay content may run as high as 10 per cent.

### Silica Used in the Manufacture of Ferro-Silicon.

Ferro-silicon is the most extensively used of all the ferro-alloys produced in the electric furnace. It is made in two ways: (1) by the reduction of silica and iron ore with carbon, (2) by the reduction of silica with carbon, the iron content being obtained by the addition of iron turnings.

The silicon required for the manufacture of this alloy is obtained either from a pure grade of quartzite, or else from a pure but low grade iron ore high in silica. Chemical analysis of a silica material for this use gives good indication of its suitability, and a material of the following analysis would be acceptable:

| | |
|---|---|
| Silica | 97.00% to 98.25% |
| Iron oxide and Alumina | 1.00 to 1.75 |
| Calcium oxide | Not to exceed .20 |
| Magnesia | Not to exceed .20 |
| Phosphorus and Arsenic | Nil |

The iron content does not greatly matter, though it should be uniform. The objectionable impurities are calcium, phosphorus and arsenic, as these are reduced in the electric furnace to calcium phosphide and calcium arsenide in the presence of carbon. These objectionable compounds remain in the ferro-silicon and, on coming in contact with water or moist air, give off phosphoretted hydrogen ($PH_3$), or arseniuretted hydrogen ($AsH_3$), both gases being very poisonous. Apart from the danger from these gases, the ferrosilicon in which they occur shows a decided tendency to spontaneous disintegration, on being stored for a few weeks, it crumbles and falls to powder, thus rendering the material useless.

The physical characteristics also have an important bearing on the suitability of a silica material for use in the manufacture of ferro-silicon. Many firms specify a quartzite, and claim that a sandstone is unsuitable; but some firms have made use of a compact sandstone when quartzite was not available. There may be a reason for this in the fact that the sandstone might possibly disintegrate into sand in the furnace, due to a weak bonding material, and thus choke the furnace; but there is not sufficient data on this point to determine the exact reasons for the prejudice against sandstones on the part of the ferro-silicon manufacturers.

It is manifest, therefore, that the present requirements of this industry in the matter of silica are (1) a quartzite having approximately the above chemical composition; and (2) a compact and dense variety, ranging in size from 1 to 6 ins., according to practice.

### Silicon in the Manufacture of Sodium Silicate.

Commercial sodium silicate, also called soluble glass or water glass, approximates to the composition—$Na_2O$, 4 ($SiO_2$) and contains about 79% silica. About $120,000 worth of silicate of soda are consumed in Canada each year, and not a pound is being manufactured in the Dominion. It is prepared, commercially, in two ways, namely, the dry and the wet methods. In the former method, a mixture of powdered quartz (or silica) and either sodium carbonate or sodium sulphate is fused at a temperature of 1100 deg. C., in a regenerative furnace, for eight hours. A small quantity of coal is added, to aid in the reduction of the carbonate. The product is tapped out when in the fused condition, into a receptacle, and allowed to cool. It is crushed and then subjected, under pressure, to long boiling with water. The resulting solution is allowed to stand, and is then evaporated to the required consistency.

In many cases the wet method is preferred, on account of the greater uniformity of the product and the fact that it is obtained at once in the form of a solution. This method consists of digesting—under pressure—silica with a solution of caustic soda having a specific gravity not above 1.24. The liquid is heated by blowing in steam, and is constantly stirred by ma-

chinery. The clarified liquid is drawn off and concentrated to the required strength.

For the manufacture of this material the silica is preferred in the form of a pure, diatomaceous earth, or else as a finely powdered flint, quartz, etc., and should be as pure as possible.

### Silica in the Pottery and Enamelling Industries.

In the pottery industry silica is an important raw material, entering into the composition of white ware bodies and glazes. For this purpose it is essential that it should burn to a dead white. A high grade material free from iron if possible, is desired. It is ground to 150 mesh, or finer, in pebble mills. The English practice is to grind flint nodules which have been calcined and dropped, while hot, into water. In America, glass sands are ground in ball mills to the required mesh.

A porcelain body may contain as high as 40 per cent of ground silica.

In the metal enamelling industry, silica is used as a partial substitute for feldspar in some of the cheaper grades of enamel. For this use it has been found, from practical observation, that the quartz is better employed when in not too finely divided a condition. The material used should contain over 97 per cent $SiO_2$, and less than 0.32 per cent iron oxide. The use of crushed sandstone, quartzite, and vein quartz or flint, seems to depend on local conditions rather than on the physical or chemical properties of the material.

### Silica in the Manufacture of Paint.

The introduction of silica into paint manufacture dates back many years, and the modern floated silica is now classed as a standard pigment. Pure silica, in the form of an impalpable powder, is one of the most stable pigments known, being highly refractory, and practically insoluble in water and acids, except hydrofluoric. It is, however, never used as a base paint, but may be added to some pigments—with the exception of siliceous ochres—up to 25 per cent; also to lamp black, the better grades of iron oxide pigments, and pure chrome green, up to as high as 50 per cent, without detracting materially from their value as a body paint.

Paints containing silica are the best for use on green lumber or material containing moisture as the silica is said to allow the moisture to pass through the pores of the paint film, while at the same time resisting external dampness. Silica is also said to increase the durability of a paint.

For paint purposes, silica with a "tooth" is preferred; and, as a rule, the clear, glassy quartz will yield a sharper grain than the opaque, massive varieties, no matter how fine the silica may be ground. The material should be well over 95 per cent $SiO_2$, and free from iron or other colouring impurities. The most essential quality for its employment in the paint industry is its colour, which should be perfectly white. The finer the material is ground the better suited it will be for paint manufacture, and, as employed, it is generally in the form of water or air floated silica, or else bolted.

The following analysis (after Scott) will serve to show the composition of silica from several sources, as used in paint manufacture:—

| | 1 | 2 | 3 |
|---|---|---|---|
| | P.c. | P.c. | P.c. |
| Silica, $SiO_2$ | 99.38 | 98.00 | 96.86 |
| Alumina, $Al_2O_3$ | .22 | .95 | .22 |
| Ferric Oxide, $Fe_2O_3$ | ..... | .05 | ..... |
| Lime, CaO | ..... | tr. | 1.30 |
| Magnesia, MgO | .08 | .15 | ..... |
| Carbon Dioxide, $CO_2$ | ..... | ..... | .69 |
| Sulphur Trioxide, $SO_3$ | ..... | ..... | .56 |
| Water, $H_2O$ | .30 | .85 | .29 |

1. Floated silica made from rock quartz.
2. Floated silica made from milky quartz.
3. Floated silica made from quartzite.

### Silica for Use as a Flux.

In the smelting of some ores containing a basic gangue, silica is introduced, along with the ore in the furnace charge, as a flux. Unless material can be obtained carrying metallics similar to those in the ore being smelted, vein quartz, quartzite, or, in rare cases, sandstone, is employed. For this use, it is desirable to obtain a rock high in silica. Usually the smelting company employing silica in a charge for the furnace, operates its own deposits, and crushes the quarried rock to the required degree of fineness.

Silica is also employed as a material for lining certain types of metallurgical furnaces, notably Bessemer converters and electric furnaces for the melting of scrap iron. Silica containing small proportions of a plastic clay, either present naturally in the rock or else added to the crushed material in the form of a plastic clay, is best suited for the purpose. The writer had occasion recently to visit a plant that was melting scrap iron in electric furnaces. For lining these furnaces a mixture, composed of crushed silica brick, crushed quartzite, and a silica sand, bonded with glucose was used. The quartzite and silica brick particles were about ¼ inch in size, and the sand was of similar texture to that used in glass manufacture, or in steel foundries.

### Silica in the Manufacture of Carborundum.

The discovery in 1885 that the abrasive carbide of silicon (SiC) could be manufactured in the electric furnace, opened up a large market for high grade silica. Carborundum, as this material is known, is produced by heating a mixture of coke, siliceous sand, sawdust and salt in an electric furnace. The charge is made up approximately in the following proportions:

| | | | |
|---|---|---|---|
| Coke | 34% | Sawdust | 10% |
| Sand | 54% | Salt | 2% |

It will be seen, that silica comprises over half the charge.

The silica is required as a sand of fairly uniform texture, graded between 20 and 100 mesh screens. Chemical analysis gives a good indication of the suitability of a sand for the manufacture of carborundum, since the silica content is of vital importance. The sand should analyze 99.5 per cent $SiO_2$, and never be lower than 99.25 per cent. While it is stated that alumina in small quantities is not injurious, lime, phosphorus, and magnesia should be entirely absent.

### Steel Foundry Sand.

Silica finds one of its largest markets in the steel foundries. Last year, in a paper on Moulding Sands presented before this Institute, the writer touched briefly on the possibilities of artificially preparing moulding sands for all classes of castings. In the case of moulds for steel castings this method is already being used. The high temperatures to which the steel is subjected in the furnace, and which it retains on being poured into the mould, necessitate the employment of a highly refractory sand; hence, although some natural moulding sands are suitable for this work, the greater number of castings are made in moulds consisting

largely of a high silica sand, to which some artificial bonding material has been added. This bonding material generally contains a highly plastic fire clay, flour, molasses, etc.

For this use, a sand running well over 95 per cent silica is necessary; and the tendency is towards increasing this percentage. Iron oxide, or other fluxing impurities, are undesirable because they tend to increase the liability of the mould to fail and aid the presence of scabs on the casting. The sand should all be passed through a 16-mesh screen, and be retained on a 100 mesh; the greater bulk being between 28 and 45 mesh.

### Sand for Sand-Blasting.

In foundry work the latest practice for cleaning large and small castings is to use a sand blast. The sand used for this work varies greatly in different foundries. One operator prefers a sharp grained sand, another a round smooth-grained sand. The sizes of grains employed also differ. An essential requirement of sand used for this purpose is that it be composed of grains of uniform size.

### Sand for Incidental Uses.

A number of other uses of silica might be mentioned, such as for dusting rough papers, the manufacture of asbestos roofing shingles, the manufacture of sandpaper, etc., but the uses already described give a sufficient idea of the economic possibilities of this material.

### The Possible Sources of Silica in Eastern Canada.

As mentioned at the beginning of this paper, the investigation of silica and its occurrence in Canada, is still under way, hence no definite information can be given as to the quality of the material obtained from the several localities in Canada. One may, however, indicate briefly the localities where possible high grade silica may be obtained.

### Maritime Provinces.

Prince Edward Island Sand.—About six miles east of Souris, P.E.I., a beach sand was obtained which ran well over 95 per cent silica, very low in iron and small quantities of undecomposed feldspar. The beach from which this sand was taken is, roughly, a mile and a quarter long, and in its widest part is probably three-quarters of a mile, tapering at both ends. The sandhills are fifteen to twenty feet high, so that there is a fairly good quantity of sand in this deposit.

### Province of Quebec.

Potsdam Sandstone in South-western Quebec.—The Potsdam sandstone which is so largely developed near the New York border between Huntingdon and Hemmingford, as well as along the St. Lawrence and Ottawa Rivers, is in many places free from iron. The grains of the rock are small and, in most cases, the material crushes readily. The best exposures, with reference to transportation, are to be found in the vicinity of Beauharnois, Melochville, Cascades Point, and in the area lying between the St. Lawrence River and Lake of Two-Mountains. North of the Ottawa River, a number of outcrops are conveniently situated with reference to the several railways, notably those at St. [illegible] and St Scholastique. Material from these deposits has been employed in Montreal and elsewhere for the manufacture of bottle-glass, for steel foundry work and for furnace linings.

St. Remi d'Amherst Deposits.—At the property of kaolin deposit consists of a highly shattered quartzite, carrying from 10 to 12 per cent kaolin in the fractures. This material is being treated in the Canadian China Clay Co.'s mill and a silica sand being produced which runs over 99 per cent silica.

### Ontario.

In the vicinity of Brockville a number of deposits of Potsdam sandstone as well as quartzites occur which, on examination in the field, seemed promising as possible sources of silica. The sandstone from this locality is compact and fine grained.

Westport Area.—In the vicinity of Westport and Newboro in the township of Crosby, North and South, there is an extensive exposure of fine-grained sandstone. In many places this sandstone is badly stained with iron, but a number of outcrops were noted in which certain beds were comparatively free from impurities. The material crushes readily to the natural grain of the sand, which is between 16 and 100 mesh.

Perth-Smith's Falls Area.—In the vicinity of Perth and between Perth and Smith's Falls another sandstone area occurs. The iron-stained beds noted in the Westport area are to be found here, but the white beds are not so numerous nor so thick.

Kingston Area.—Between Kingston and Gananoque on the St. Lawrence river and north-westward to Sydenham, there occur a number of outcrops of Potsdam sandstone. Many of these beds are fairly white and uniformly free from iron stains. In several of the outcrops the white beds are of considerable thickness, and could be readily quarried without producing an excessive amount of waste material.

The Oriskany Sandstone Area.—In the vicinity of Cayuga there is a narrow belt of Oriskany sandstone, running northwest, which at one place (Nelles Corners) is already being quarried and manufactured into a glass and steel foundry sand. The material carries a small quantity of brown coloring material (presumably organic matter) which burns out in the furnace.

---

## PRICE AGREED UPON FOR ALUMINUM.

The War Industries Board authorized the following statement:

The President has approved an agreement made between the producers of aluminum and the price-fixing committee of the War Industries Board (after investigations by this committee in conjunction with the Federal Trade Commission as to the cost of production) that the new maximum base price for aluminum, effective June 1, 1918, to September 1, 1918, shall be 33 cents per pound f.o.b. United States producing plants, for 50 tons and over, of ingot of 98 to 99 per cent. Differentials for sheet, rod, and wire will be increased by approximately $12\frac{1}{2}$ per cent; differentials for quantity and grade and differientials for alloys will remain as heretofore, i.e., those approved by the price fixing committee of the War Industries Board on March 3, 1918. Copies of the new list of differentials may be obtained upon application to the non-ferrous metals section of the War Industries Board.

# Some Problems of Modern Industry

By W. L. HICHENS

(Chairman of Cammell Laird & Co., Ltd.)

**Being the Watt Anniversary Lecture for 1918, Delivered Before the Greenock Philosophical Society on 18th January, 1918.**

It is a true instinct which leads us to set apart certain days in each year to commemorate the famous men of our race, for, in Carlyle's words, "the history of what man has accomplished in this world is, at bottom, the history of the great men who have worked here." The hero is essentially a man who realizes truths to which others cannot or dare not attain, whose torch lights up the dark places of the earth, who substitutes reality for what has become a sham. It is well, therefore, that we should remind ourselves, on solemn occasions, what manner of men these were. It is well, too, that their glory should live in our minds, for admiration of others is the first condition of excellence in ourselves. "See the good in other people's work," cries R. L. Stevenson, "it will never be yours; see the bad in your own and don't cry about it; it will be there always." In these islands a highly developed critical faculty is one of our most noticeable characteristics. We are more apt to find fault with those around us than to praise them: we admire perhaps in silence, but the spoken word is often dismally censorious. With us criticism rather than charity begins at home, and our admiration radiates outwards in waves that leave our immediate surroundings untouched. We often fail to recognize our great men when they are amongst us. A Kay invents the fly-shuttle which enables a weaver to double his daily output, and what is his reward? He is wrapt in a blanket and conveyed furtively from his home at dead of night in a coal cart. Eventually he is smuggled in a fishing smack to France, where he ends his days in poverty and is buried in an unknown pauper grave.

"And Bahram that great hunter the wild ass
Stamps o'er his head, but cannot break his sleep."

It is fitting therefore that if we cannot appraise the worth of men while they live, we should commemorate their virtues in the aftertime and draw inspiration from the truths for which they fought.

We are met here to-night to do honor to the memory of Jas. Watt, whose commanding genius was more fortunate in this respect in that, after many an uphill struggle, it triumphed over opposition and won the admiration of the British world before his death at the ripe age of 83. He was not merely a great scientist, a great seer of truth; he was able to translate great thoughts into action, which is a far rarer gift. One is struck by the wide variety of his interests, by the breadth as much as by the depth of his knowledge, and therein perhaps lies his real claim to greatness; for your man of one idea—your narrow-minded man—will never achieve greatness; he will never even be human —and a man must be human before he can be great. This point is sometimes lost sight of in the educational controversies of to-day, for a vocational training is too often urged at the expense of the broad foundations of knowledge, which are essential to a true understanding of life and the development of that harmony which is in immortal souls.

"The man that hath no music in himself
Nor is not moved with concord of sweet sounds,
Is fit for treasons, stratagems and spoils;
The motions of his spirit are dull as night
And his affections dark as Erebus:
Let no such man be trusted."

James Watt lived at a time when the industrial world was in course of rapid transition. Indeed his invention of the steam engine may be said to have been one of the prime causes of the industrial revolution. The industrial policy of the Elizabethan age still held the field, although it was seen by more advanced thinkers to be wholly unsuited to the changed conditions of 18th century life. The garment was threadbare and fitted extremely ill, yet men clung to it with all the obstinacy of conservatism and inertia. One of the great problems of human life is that social needs and conditions change more rapidly than the institutions in which they have their setting. For nations never grow old in spite of what history books tell us; it is their institutions which decay—and this is a very different thing. Humanity is always young; it is forever renewing its youth; it never ages. But its institutions become threadbare; and the trouble is that we cling to our old clothes long after we have outgrown them, until one fine day they burst and we discover in naked shame that we have not had the foresight to fashion a new garment.

The industrial policy of the Elizabethan age was based on state regulation. Under the statute of apprenticeship each trade tended to become a narrow and rigid corporation, for no man was allowed to work at a trade unless he had served an apprenticeship of seven years. Watt, himself, is a classical example of the absurdity of this system, for, as everybody knows, he was refused permission by the Corporation of Hammermen to ply his trade in Glasgow on the ground that he was not fully qualified, and had it not been for the enlightened attitude of the Glasgow University, which allowed him to establish his workshop within its walls, his career might have been very different.

Wages, again, were under the law fixed by Justices of the Peace in each district, and all grievances were carried direct to Parliament, which was largely responsible for controlling prices. All combinations of workmen and of employers to regulate labor conditions were forbidden. But state intervention did not stop here, for the "laws of settlement" prevented the free circulation of labor, and to a great extent confined the poor to the parishes in which they were born.

These restrictions may possibly have suited the conditions of the 17th century, for the population of Wales and England was under 6 millions in 1700; the number of trades was small, and the factory system was unknown. Moreover, the distinction between capital,

the entrepreneur class and labor, had not arisen in industry and to a large extent each skilled workman was a combination of all three. He was really a small contractor working in his own house, owning his own tools, buying his own raw materials, and selling the finished article. The wage system therefore as it is now understood scarcely existed among skilled workers in industry. In fact the craft guilds, as Mr. Sidney Webb has pointed out in his History of Trade Unionism, were unions, not of wage earners, but of producers, who combined the functions of capitalists, entrepreneurs and workmen. The pin makers, for example, worked in their own houses, purchased their own wire, owned their own tools, and sold the finished article to wholesale merchants.

But the industrial policy of the Elizabethan era had become unworkable long before Watt's time, although it was not until 1776 that it received its deathblow by the publication of Adam Smith's "Wealth of Nations." Nor was death even then instantaneous, for it lingered on with many writhings and contortions until the early part of the 19th century. The statute of apprentices, in so far as it empowered justices of the peace to fix wages, was repealed in 1813, and the apprenticeship clauses of the Act disappeared in the following year. The hardships of the Acts of Settlement, restricting migration from one parish to another, were largely mitigated in 1795, and the laws against combinations, which did not reach their climax of severity until 1800, were only repealed in 1824, chiefly through the efforts of Francis Place, only to be re-enacted in a modified form in the following year. Since that date, however, associations for the purpose of regulating wages and hours of labor have been recognized by law, and, in consequence, the great growth of Trade Unionism, which was destined to play so important a part in the history of Industry, was made possible.

Thus, after many convulsions and much bitterness, the Elizabethan policy of state control was at last overthrown, the old tight-fitting clothes were rent asunder and discarded, and the opposite fashion was adopted. The State abdicated at the instance of the political economists, and "laissez faire"—or economic individualism—reigned in its stead. The theories of Adam Smith and the more cold-blooded Ricardo were proclaimed from the house tops, and lost nothing in the telling. In fact the industrial world suffered from an orgy of unbridled liberty, and life became an unregulated scramble for the good things of this world. But the results were not what the Political Economists had anticipated, and it was soon seen that the interests of the individual, if left unfettered, were not necessarily those of the community—in fact that there was a most unscientific and embarrassing conflict between the two.

Public opinion therefore stepped in and the principle gradually reasserted itself that the State could not be a mere spectator at the gladiatorial contests of economic individualism. The Factory Act of 1833 marks the beginning of the new era, and, from that date until the outbreak of the present war, State control over industry again steadily increased, beginning with modest regulations affecting the condition of factories and the working hours of women and children and advancing with ever quickening step to truck acts, corrupt practices acts, the establishment of sickness and insurance benefit, employer's liability, labor bureaux, and the fixing of wages under the Trade Board Acts and the Coal Mine (Minimum Wage, Act. Since the War the pace has become fast and furious, and State control has advanced by leaps and bounds. The State limits the profits of employers, it determines wages, it fixes the price of provisions and staple commodities, it undertakes the purchase and distribution of certain raw materials, it has taken over the railways and coal mines, it controls shipping and shipbuilding. A far cry this from the economic individualism of Adam Smith and his school! In fact the wheel of destiny has revolved, and we are back again at the policy of the Elizabethan era, when the State assumed responsibility for directing the lives and controlling the activities of its members. For the past 400 years we have tried one expedient after another, State control of wages and prices, co-operative guilds, the home industries system, the big factory system, economic individualism—only to end up where we began. Are we to conclude, then, that there is nothing new under the sun and that our brains are beguiled—

> "Which laboring for invention, bear amiss
> The second burden of a former child."

Not that, at any rate: for in human affairs it is truer to say that everything under the sun is new. Human conditions are so infinitely various, the permutations and commutations are so incalculable, that the same experiment can never be performed twice over, and the fact that these experiments failed in the past is no evidence that they would not succeed to-day.

But something clearly has been wanting to their success in the past; something abstruse and elusive perhaps, or possibly something so obvious that, as Socrates found in his search for Justice, it has been under our noses all the time. Might it be that in seeking to solve these social problems primarily by legislative measures and mechanical devices, or by a precise adjustment of relations based on force or self-interest. We are putting the cart before the horse?

Faust after mastering philosophy, jurisprudence, and religion, failed to find the key to knowledge—and betook himself to magic. Possibly we too should pay less attention to the pursuit of pure reason—should think less in the head and more in the heart—for it may be that the solution of this industrial problem, which is by far the greatest that we are called upon to meet, lies beyond mere intellectual and legal formulae, beyond all economic laws and doctrines, and depends on our attitude towards social existence—in plain terms on our moral code.

The god of industry, according to the political economists of the early XIX century, is the golden calf—mammon "the least erected spirit that fell from Heaven"; and an unrestricted scramble for the good things of this world was what they set before each individual as the law of life. Such a doctrine strikes at the root of the social organism.

For the whole basis of human existence is organized association. As one of your Scottish philosophers has said, "without the sense of solidarity, of community, of fellowship, the fortunes of man in this world would be low and brute-like." All art, all science, music, poetry and philosophy, our traditions, our schooling (rightly derived from schole leisure—leisure from the grinding toil of providing our daily bread)—our language, even, we owe to our social relations. The great

problem of life is to reconcile the contradiction between our social and our individual instincts, and it is according as their citizens succeed or fail that states rise to greatness, or decay. The higher and more elaborate our civilization becomes the greater must needs be the solidarity that welds it together—the completer the subordination of the individual to the community. And the choice must be freely and deliberately made; its direction cannot be forced; it cannot be left to instinct. For we have eaten of the fruit of the tree of the knowledge of good and evil and the choice lies with ourselves. Were we as the ants this choice would not present itself, but it is just the power of choosing that makes man greater than the angels.

No man can serve two masters: he cannot serve himself and the community; for then the kingdom would be divided against itself; he can only serve himself by serving the community, and this is surely the only sound foundation on which industry can rest. If we are ever to solve the great industrial problem it can only be by recognizing that industry is primarily a national service, and that the object of those engaged in it is first and foremost the good of the community as a whole.

"Yes," it is often urged, "that is all very true and obvious, but it is so hopelessly unpractical. The incentive of gain is so deeply implanted in the human breast that it cannot be destroyed, and if the opportunity for individual profit is taken away by legislation the main incentive to thrift, economy, and efficiency will disappear with it." There is, undoubtedly, much force in the criticism. It is obvious that social service must come before individualism—so obvious, indeed, that the fact is often overlooked. But it is not taught, as it should be, in our schools or even in our churches. The creeds which we repeat in church do not contain one word as to the Christian belief on the subject of our duty towards our neighbor, and if we ask why we ought to obey this great commandment we are too commonly put off with the answer, "Because it says so in the Bible and because if you don't you will go to hell and burn." The hope of dazzling rewards and the fear of eternal punishment in another world have placed far too prominent a part in religious teaching; and this has led religious minds to stress unduly the evils of our present state. We are taught to regard this world as a vale of sin and woe and man as a miserable and hateful sinner, whilst our minds are not allowed to dwell on the inspiration that can be drawn from the beauties of nature and the grandeur of humanity—although herein lie the great truths of existence. No on is really satisfied with the ideal of purely individual salvation, either here or hereafter, as the final motive of conduct. The mainspring of all political philosophy and of human existence is to be found in a single sentence uttered by the greatest philosopher of all time—"If ye love me keep my commandments." Love of God and love of man are the bases on which human society rest; they are the final motives of right conduct. Without them all societies crumble and the world becomes the pandemonium it is to-day.

It is, of course, true that the full ideal of social service is unattainable by fallible men; but so are all ideals, for, like the horizon, "their margin fades forever when we move." That, however, is no reason for discarding ideals in the practical affairs of life. No sensible man would suggest moreover that all opportunity for individual profit should be taken away by legislation. For to destroy the existing incentive without putting something in its place is merely to leave the chamber of men's minds swept and garnished—a prey to seven devils worse than the first. Legislation cannot make beliefs; these must be determined by each individual concsience for itself, and legislation can only express what the public conscience has already accepted. Besides, it is not suggested that all opportunities for individual gain ought to be eliminated—only the good of the indivirual should come after, not before, the good of the community where the two conflict. The example of those who are daily sacrificing their lives for the sake of their country points the way for the rest of the nation to follow — not merely in war, but in peace — and it is stamped so deeply in our hearts that we can never forget it, or be false to their memory.

I have stressed this point unduly, you may think, and with wearisome iteration, but to my mind it is fundamental. Unless industry is really recognized as primarily a national service, in which each individual is fulfilling his function to the best of his ability for the sake of the community, in which private gain is subordinated to public good, in which, in a word, we carry out our duty towards our neighbor—unless we build on this foundation, there is no hope of creating the House Beautiful. If each man thinks of making his pile by all the means that economic individualism allows, if class bands itself against class, trade union against employers' federation, firm against firm, to secure the greatest share of the world's goods in unrestricted competition, social life must inevitably break down and anarchy reign supreme.

May I now indicate very briefly some of the practical steps that this principle seems to suggest in relation to certain of the problems that confront industry to-day? (1) I think it follows that no business is entitled to make unlimited profits. The present theory is that the residuum, however large it may be, after defraying the costs of production, should go to capital. This I submit is unsound. Labor, the entrepreneur class, capital and the consumer, are all partners in the business of the community, and no one class is entitled to benefit unduly at the expense of another. The principle of the profits tax should therefore be retained after the War. The present tax, of course, was intended as a temporary measure, and a standard of profits based on pre-war earnings is quite unsuited to permanent conditions. It would be necessary to fix a standard rate of interest for the capital invested in each class of trade or industry, and a proportion (I suggest a substantial one) of any excess profits over that standard should accrue to the State. In any such scheme it would be necessary to provide that adequate allowances are made for depreciation and for reserves to secure the stability and development of business. The wholly inadequate provision for depreciation allowed under the income tax regulations to-day has, I believe, done serious injury to the industries of this country. It has encouraged over-capitalization; it has hampered the scrapping of old and substitution of modern machinery; it has given us a retrograde in place of a progressive standard. It would be easy to spend the whole of my allotted time in discussing the arguments for and against this proposal, but I must content myself with the observation that effect must somehow be given to the principle that no section of society is entitled to an unlimited share of the wealth of the

community, that free competition has proved an impossible solution, and that profit-sharing with the State which is what, in the effect, an excess profits tax is, is more equitable and more expedient than other forms of profit sharing.

2. It follows secondly that, just as capital is not entitled to an unlimited reward but must be checked by State action, so also the reward of labor must, in the last resort, be determined by the State, as representing the community. Labor has no more right than capital to make a corner in its own commodity and hold the community up to ransom, and it too must bow to the will of the State. In practice it is clear that the tendency will develop for wages to be settled by joint Industrial boards representing employers' and workers' organizations, but in the event of disagreement, or collusion to exploit the community, the State must have the right of intervention. It is not fitting that any party should be the final judge in its own cause, and any such claim, if successful, will inevitably lead to the disintegration of society. For the community will be divided into a number of groups each fighting for its own hand, private gain will rise superior to the public good, the fundamental law of social life will be broken, and the eternal truth will be verified that a kingdom divided against itself cannot stand. I recognize that a large section of the community is not, to-day, prepared to accept the principle of State intervention, and I recognize also that unless it appeals to the moral judgment of the great majority of the nation it cannot be enforced, and ought not to be enforced. The important thing to-day is that the verdict of public opinion should be sought.

(3) The principle of national service requires thirdly, I submit, that the status of labor as a whole should be raised. The workers are clearly entitled to have an effective voice in regard to the general conditions under which their work is carried on. They are vitally interested in all questions, for example, affecting wages, hours of labor, apprenticeship, demarcation of work, decasualization, and they have an equal right with employers to assist in the determination of these problems. The general acceptance of the proposals for Joint Industrial Councils contained in the Whitley report is good evidence that public opinion will support the demand of labor for an improved status. If its voice is to be at all effective it follows that, as suggested in the Whitley report, district Councils and Works Committees must be established to deal with local questions and to ensure that whatever is agreed to by the Central Councils is carried out locally. The more highly organized Employers' Associations and Trade Unions have already advanced far along the lines of the Whitley report, but much has yet to be done in determining precisely the powers and functions of these joint central and district bodies.

There are two points in particular which, it seems to me, deserve careful consideration. The first is the interpretation of decisions in regard to wages. At present all general increases in time rates are determined by the Government and incidentally I may say that it is a grave defect in organization that so many Government Departments meddle in labor matters. There should be one Government Department only —the Labor Department—to deal with labor questions —not half a dozen, and this salutary reform would save great confusion and waste of money. There is in fact a serious lack of co-ordination between the Government Departments. New Departments have been thrown down as from a pepper pot, without a clear definition of their functions or their relations to the older Departments and each other, with the result that, as in the game of animal grab, when the same card is turned up by two or more players, a discordant noise ensues for the appropriation of the spoils, and all are as intent on the game as the boy in Theocritus, who pays no heed to the wily fox that designs to rob him of his breakfast. The solution, I submit, is a cabinet for internal affairs distinct from, though subordinate to, the War cabinet, with a president of its own whose business it should be to co-ordinate the administration of domestic policy. This would give relief to the overburdened War Cabinet, and allow serious and orderly consideration to be given to the vast internal problems with which we are faced. But this is a digression, and I return to my point which is that, while general increases in time rates are to-day settled by the Government, individual firms still determine time rates in particular instances and all piece rates, which in theory should bear some definite relation to time rates. Thus the door is left open for one firm to pilfer from another, and, since leaving certificates have been abolished, the temptation has not always been resisted. It is obvious that the firms whose piece rates are highest will attract most labor, with the result that other firms will be obliged to follow suit, and this will eventually react on the time rates. Similarly in periods of depression when labor is plentiful, individual firms can cut their piece rates, and compel others to follow suit, or lose their trade. The strongest justification for restriction of output is that individual firms have it in their power to cut down piece work rates, and in the past they have often done so, when they found that under them the workers were earning very high wages. Consequently the workers have felt that, in the end, the result of increasing output and speeding up has been to reduce the piece work rates, and restore the normal balance of their earnings; not unnaturally, therefore, they have concluded in favor of maintaining a normal output of work. It is quite clear that a mistaken piece rate must be open to revision downwards as well as upwards, and the pledge given by the Government at the beginning of the war that no piece rates would be reduced was a benevolent blunder.

What they should have done was to ensure that piece rates were not arbitrarily altered, and that due care was exercised in the fixing of all rates. During the War some bad individual mistakes have been made, which have reacted on industry as a whole. It would seem, therefore, on all grounds, that the responsibility for fixing piece rates and special time rates—in other words for the detailed interpretation of wages agreements—should rest, not on individual firms, but on the joint District Councils, which are to be linked up with the joint industrial Councils This would mean that these Councils would require a competent staff of rate fixers to deal with each case promptly, but a more than corresponding reduction could probably be made in the rate fixing staffs of individual firms, and the gain that would results from placing the settlement of piece rates on a basis that would establish confidence, is incalculable. If time allowed I should like to show how the example of the cotton industry, and the fixing of general "list" prices in the shipbuilding industry, demonstrate the practicability of this proposal; I should like to point to the

success which has been achieved in fixing piece rates by the wages boards n sweated industries; and I might demonstrate that collective rate fixing is the logical outcome of the shop stewards movement which has gained recognition.

But I must pass on to the second point in the relations between organized labour and employers to which, I think, special attention should be directed by those interested in these problems. It is sometimes claimed that labour should have an effective voice, not merely in regard to the general policy and conditions of industry, but in the management of each individual business. This claim is vaguely put forward, and has never been clearly thought out; it makes its appearance, usually, under the guise of a demand for the democratization of industry. The political analogy implied in this phrase is, I think, attractive but misleading. For whereas a State cannot at one and the same time be an autocracy, an aristocracy, and a democracy, it is possible for every variety of organization to coexist in industry. The general policy and conditions of industry should, it is true, apply to each firm in an industry, and therefore it is right that labour should have an effective voice in determining them, and seeing that they are carried out, through joint industrial Councils and district Committees. But every degree of variation is possible in the detailed organization of individual businesses. One may be an autocracy built up by the genius of a remarkable personality; another may be organized on co-partnership lines, and another on the lines of a co-operative store. There is ample scope in industry for everyone to select or develop the type of organization that suits him best, and it seems to me that each man is entitled to choose for himself. Unrestricted competition is an evil, but its complete elimination spells stagnation; for a healthy rivalry between one type of organization and another, and between one firm and another, is the lifeblood of efficiency. Hence, subject to the observance of the general policy and conditions of industry, I think that each business should be organized on whatever lines seem best to those who are responsible for its direction. I do not agree, for example, with the suggestion so often made, that the power of dismissal is too big a responsibility to be exercised by any single employer, and that there should be a right of appeal to some outside body. I admit to the full the evils of insecurity of tenure, and hold that every effort should be made to remove this nightmare of uncertainty which oppresses the wage earning class. But the root cause of it is, not the right of the management to employ whom it pleases, but the fluctuation in supply and demand, which can never be wholly controlled, although much more can be done than has ever been attempted. Meanwhile, it is clearly right that the evils of unemployment should be mitigated by a wide extension of unemployment insurance benefit. Division of labour is essential to the organization of modern society, it is required in the interests of the community as a whole, and unemployment benefit should be administered from one central fund. It is reasonable that each worker should contribute a percentage of his pay and each firm a proportion of its wages bill to the fund, but it is reasonable also that the general public should contribute. To regard each industry as a separate unit, with a separate financial responsibility, would, I believe, be a serious blunder, tending to restrictions of interchange similar to those brought about by the laws of settlement and the apprenticeship laws of the 17th and 18th centuries.

But, given an adequate system of unemployment benefit, I submit it is vital to the success of industry that those responsible for the management of a business should be entitled to select their own employees. The secret of success in business lies very largely in the wise selection of men, and, if that responsibility is taken away from the management, a blow will be struck at the very roots of our industrial supremacy.

(4) I come now to the fourth point in the application of the general principle of national service, and it is, strictly speaking, rather a necessary preliminary to, than a consequence of, the principle. I refer to the question of the reduction of hours of labour, which I venture to think is one of the most important problems awaiting solution. Under modern conditions, very large numbers of men and women are engaged on work of unalloyed drudgery, and the progress of specialization and automatic machinery, which is inevitable, will increase rather than reduce the monotony of labour. Leisure hours, therefore, become of increasing importance, for man is not a mere machine; he is by nature many-sided, and his different faculties must be given an opportunity for development and expression in any really healthy community. The idea of the leisured classes and the toiling masses is monstrous; it is just the toiling drudge who needs leisure most—leisure for recreation and refreshment, leisure for education—above all, leisure for education. For education is not something which ceases with boyhood; the roots only are planted in early youth; the flower and the fruit ripen in after life, and how can they ripen if they are choked by the dense jungle of drudgery? How can a man understand the meaning and the beauty of life, how can he feel the inspiration of patriotism, if he sees the world only through the clouded spectacles of drudgery? The first step on the return of peace should, I believe, be the establishment of an eight hour day, as a first instalment towards still farther reductions, if experience shows that this is possible, consistently with the material requirements of civilized existence. Moreover, it should, I think, be arranged that each worker, who has been with a firm a whole year and has kept good time, should be given a holiday on full pay. The distinction between a strike and a holiday should be more marked than it is now, and the same absence of pay should not characterize both. No doubt the leisure thus acquired will at first be abused by many, and the proverb that Satan finds some mischief still for idle hands to do, will be freely quoted; but no one can attain to the Delectable mountains without passing by Doubting Castle.

(5) But the reforms indicated above will require large sums of money, and there are many others to which I have not alluded, such as housing and education, the cost of which will be formidable. Moreover, these reforms will be of little or no avail unless a high standard of wages is established. Seeing that we are so largely dependent on our foreign trade, in which prices are regulated by international competition, it is quite clear that we shall not be able to meet the bill, unless we can effect drastic economies in production and largely increase out output. One way of increasing the national output has already been referred to. If all strikes can be prevented and regarded, as they should be, as the unhealthy excrescence of a semi-

civilized age, the addition to our national wealth will be very great. An average of 18 million working days per annum were lost owing to trade disputes in the four years before the war, to which must be added the indirect losses involved by the dislocation of industries not primarily affected. But an even greater gain will be made if the policy of restricting output is abandoned. The loss that falls upon the community owing to "slow timing" and indifferent workmanship is an oft-told tale, and I will not dwell on it. But disastrous though the policy is to the workers themselves, as well as to the rest of the community, we shall, I believe, be indulging a vain hope if we think it will be abandoned so long as the theory holds the field that capital is entitled to the residuum of profit after the costs of production have been defrayed. Unless it is made unmistakeably clear that industry is run for the benefit of the whole community, and not for the enrichment of certain classes, restriction of output will continue, and the reforms that are so urgently needed will be sadly hampered. Similar in kind —and far less excusable—is the loss that falls upon the community owing to the existence of able-bodied drones, rich or poor, who contribute nothing to the common stock, but live in idleness upon the fruits of other men's toil.

A third important factor in improved production is the substitution of up-to-date machinery for old, and the extension of labour saving devices. Before the war, it often happened that it did not pay to introduce labour-saving devices, because, apart from the difficulty of raising fresh capital, the interest charges came to more than the cost of cheap manual labor. If the industries concerned could not bear the extra charge, as was the case in many sweated indutsries, the consumer was at fault, because he was paying too low a price for the commodity, and State intervention was justified. For it is clearly in the general interest that machinery should be substituted for hand labour wherever practicable, just as it is a social duty to secure that no one is paid a wage below what will support a civilized existence. In fact, the latter cannot be secured without the former; for it is machinery which frees us from the unremitting toil that the winning of our daily bread otherwise demands.

But just as we have been backward in substituting mechanical devices for unskilled labour, so we have been slow to replace antiquated with modern machines. In both cases want of capital, cheap labour and the opposition of the workers have stood in the way. This opposition on the part of those who may be thrown out of a job is not unnatural, and must be met partly by extending unemployment benefit, as indicated above, and partly by special provision to safeguard the interests of those displaced.

But it would be a mistake to suppose that the opposition to the reforms involved in the introduction of improved mechanical devices and improved organization comes from the workers alone. Vested interests play an even more powerful part in thwarting progress, and ingrained habits present a formidable obstacle to far reaching schemes of reform. It is essential, however, that all difficulties should be overcome, for the possible economies are enormous. Let me give a few examples taken at random. One of the paramount necessities of this country is cheap transport, and attetnion must be concentrated on reducing railway rates. Can anyone doubt that by standardizing our locomotives and wagons; by establishing central coal depots; by concentrating our goods yards; by substituting electric traction for locomotives in which only 15 per cent of the original energy is utilized; by eliminating wasteful competition; can anyone doubt that, by a far-sighted scheme of reform, a vast field of economy may be opened up in the administration of our railways?

Or, again, take the transfer of landed property. A simple and cheap method of land transfer is of great importance to a progressive community. And yet it would be hard to find any country where the system is more cumbersome or expensive. It is estimated that over £4,000,000 a year is spent in lawyers' fees alone under the present system, whereas a scheme of universal registration would be cheap, simple and expeditions.

But most important of all for industry is the supply of cheap coal and cheap motive power. The greatest asset that this country possesses is its coal, and, unless this can be produced cheaply, our economical supremacy will be jeopardized. In fact, it is probable that the steady rise in the price of coal during the last 30 years has done more than anything else to influence the decline in our foreign trade. Every effort therefore that science can devise must be made to cheapen the production of coal, and it is of national importance to secure that neither the coal owners nor the miners are allowed to drain our life blood by exacting too heavy a toll from the rest of the community. But economies must be affected not merely in the production of coal, we must also learn to use it less wastefully. In an interesting report recently published the Coal Conservation Sub-Committee of the Reconstruction Committee point out that the annual consumption of coal in this country is 189 million tons, of which at least 80 million tons is used for power purposes alone. If a comprehensive system of electricity supply were carried out they estimate that a direct saving of 55 million tons a year could be effected, which is equivalent to some 15 million horse-power or, taking coal at 10s a ton, to 27½ million pounds sterling. And the indirect economies due to reduction in transport, the utilization of by-products, the extended use of electric power, etc., are put at a higher figure still. In all, they foreshadow a possible national saving of 100 million pounds sterling per annum.

These are staggering figures, but results just as startling might, I believe, be attained, if attention were concentrated on mechanical improvements in other trades.

There is one further instance of wasted effort, to which I should like to refer briefly, because I believe it is of far-reaching importance. I mean the waste involved in unrestricted competition. Certain forms of competition are healthy and cheapen production, but others are sadly wasteful. The rivalry in economical production—so long as wages, hours and general conditions of work are safeguarded—seems to me healthy and I believe that it is better for a country to have a large number of small manufacturers than a few big trusts: this also accords more with the genius of our race, whose sturdy independence and self-reliance has built up an Empire containing a quarter of mankind. Nor do I believe that the economies resulting from manufacture on a gigantic scale are very great. It is necessary, of course, that an economic unit of

production should be established in each case, but the economic unit is not necessarily large. For example, many small firms have proved that they can manufacture shell at least as cheaply as the largest organizations. A great source of wasted energy today is that so many manufacturers are engaged in a miscellaneous trade, with no economic standards. A dozen firms may each be manufacturing a dozen types of articles at a loss, whereas, if each concentrated on one type, the loss would be converted into a profit. Moreover, standardization of types has been sadly neglected and quite unnecessary variations have been allowed to intrude themselves, merely because it is nobody's business to see that they are reduced to a minimum.

But big selling organizations are undoubtedly, I think more economical than small ones. What is wanted, therefore, I suggest, is big selling combinations, which should also promote research work, and a variety of manufacturing units. The money that is wasted every year in advertising, in travellers, in touting for orders by means which are often degrading, in over production, runs into enormous figures. But the remedy of syndicating the produce of each industry is, I admit, full of difficulty; it tends to stagnation, to the exclusion of newcomers, and to inflation of prices; for the evil of rings in the past has been that they have thought more of keeping prices up than of cutting costs down. I will not weary you further, at the end of a long address, by an attempt to show how far these evils can be overcome, and will content myself with saying that I believe they are not insuperable, and that attention should be concentrated on the establishment of big selling organizations. The principle is not, of course, immediately applicable in all industries, but it might be applied at once, with great advantage, to many of the standardized trades, and it might be encouraged where it already exists. Otherwise it will be impossible for British industry to hold its own abroad against the big trusts and cartels of other nations, and, what is even more important it will be impossible to take effective action to prevent overproduction.

I have only referred to a few of the ways in which production can be greatly increased and large economies can be made. Instances might, of course, be multiplied, but I hope I have said enough to establish the fact, which I believe to be profoundly important, that it lies in our power to realize a material prosperity far in excess of what has gone before, at a far smaller expenditure of effort, and without the crutches of a protective tariff. The fruit is within our reach; but the hand, eye, and brain of the body politic must combine, in unity of purpose, if we are to grasp it; and, above all things it must be made abundantly clear that the fruit is not intended for the exclusive enjoyment of one member, but for the whole body. Hence it comes that no tinkering scheme of piecemeal reform will avail to cure our ills; the light must be let in on all dark places at once; the muddy pools of class selfishness must be cleansed; the self-sacrifice of our soldiers and sailors must find its counterpart in our industrial life.

---

Graphitic carbon, the most important softener of iron, disintegrates the molecular structure of iron and consequently weakens it. Reduces both liquid shrinkage and solid contraction. Greatly impairs density.

# EDITORIAL

## MANUFACTURE AND USES OF ALLOY STEEL.

When the time arrives for the supply of munition steel to be a thing of the past manufacturers will look around for other outlets for the products of their plants, and even now signs are not wanting that serious attention is being given to the matter. Alloy steels may be credited with creating a revolutionary action in various industrial fields where steel performs an esential function. Probably all elements, except those classed as very rare, have been alloyed with iron, either alone or in combination with others in efforts to produce useful alloy steels. The life of some of these products has been ephemeral, but might have been prolonged had not some more satisfactory steel been discovered. Mushet produced an alloy steel in 1868 which derived its self-hardening characteristic from the addition of tungsten; some fifteen years later chromium steel made a bid for recognition, and in 1882 Hadfield developed his manganese steel. In the cases of tungsten and chromium the influence of the alloying element was proportional to the quantity added, but not so with manganese. Hadfield demonstrated that the influence of an added element may not be proportional to its content, and in his first patents covered alloys of iron with from 7 to 30 per cent of manganese, but the commercial meaning of manganese steel to-day is a variety of iron containing from 11 to 14 per cent of manganese, and from 1.0 to 1.3 per cent of carbon. Eight of the most important alloy steels are given chronologically below and their widely comprehensive characteristics will be recognized at a glance:

I.—Simple tungsten steels.
II.—Simple Chromium steels.
III.—Manganese steel.
IV.—Simple nickel steels.
V.—Nickel-chromium steels.
VI.—Silicon steels.
VII.—High speed tool steels.
VIII.—Chromium-vanadium steels.

An analysis of this list discloses the fact that one, two, three, four, and six are ternary steels, whilst seven is of a complex composition, and five and eight are quarternary. With such a field, although much has already been accomplished, the investigator will find himself provided with almost endless problems; the satisfactory solution of any one special series of alloys may have the most far-reaching and beneficial results. In the production of steel one, or more, elements are added possessing a stronger affinity for oxygen than iron has at steel-melting temperatures. The oxygen leaves the iron and seizes upon these added elements, forming new products insoluable in the iron, which in time are precipitated and pass into the slags. Unfinished steel contains in solution a quantity of gases which must either be decomposed or kept in solution, because otherwise when the steel is solidifying part of these gases will be imprisoned in the metal and form gas holes, commonly called blow-holes. Then there is a tendency for some of the ingredients of steel to segregate in the upper or central portions of an ingot or casting, but the addition of certain elements tends to minimize this action. Amongst the elements added to prevent, reduce, or cure these ills are manganese, which is the most important, silicon, aluminum, titanium, and vanadium. The aim of these additions is therapeutic, and though very real and valuable, must be looked upon as negative rather than positive, in other words, effort is made to cause the steel to be free from some or all of the inherent defects. Steels so treated are classed as alloy-treated steels because the amount of an element added is not usually sufficient to influence the physical characteristics of the metal. The elements silicon and vanadium are examples, both being used to cure ills in the steel, but both of these elements used in varying proportions, have uses in undoubted alloy steels possessing unique properties. The development of alloy steel and the heat treatment of steel have simultaneously been advancing during the past 30 years, with few exceptions all alloy steels are heat treated for use, such treatment developing in them the high physical properties they are capable of possessing. Some confusion seems to exist as to how far the alloy or heat treatment must secure credit for the enhanced physical characteristics, but undoubtedly the highest merit will be obtained by the adoption of both developments together, but usually the heat treatment will be found to have contributed more to the superior properties of the metal than has the use of alloys. The manufacture of alloy steels, their properties and uses, methods of working, and their most suitable thermal treatment opens up an almost endless field for investigation, and it will be found one of the most profitable and satisfactory enterprises when normal conditions again prevail.

## LECTURES ON IRON AND STEEL METALLURGY.

Arrangements have been made for a course of twenty lectures to be delivered at the McGill University during the coming winter by Mr .W. G. Dauncey. They will be devoted to the practical manufacture of iron and steel and it is intended to follow the synopsis given below which, it will be seen, covers all the more important operations incidental to the production of commercial iron and steel. The steel authorities, the public, and the press have received favourably Mr. Dauncey's past efforts, and it is hoped this course of lectures may be of assistance to many engaged in the iron industry; that the younger men will avail themselves of this opportunity to acquire a knowledge of the laws that govern their daily operations, and that the progressive policy of the University will be recognized and appreciated. It is essential that we realize the imperative necessity of being prepared for the conditions that will follow the war, and the education of the artizan class is going to be one of the most potent factors in enabling us to take and hold our true place amongst the nations. The natural wealth of Canadian resources must be exploited along the lines that are indicated by the latest scientific knowledge, and wasteful and unnecessary operations must be eliminated. That the problems surrounding the full utilization of Canadian resources are being recognized and grappled with becomes more apparent every day, and in this connection the importance of technical education cannot be over-estimated. The men who have grasped the meaning and effect of their daily operations are the men whose intelligence is going to enable them to expedite results and to improve processes, and whose efforts will ultimately lead to the discovery of newer, simpler, and cheaper methods of obtaining a desired result. The wide, and ever widening, cycle of operations that must be completed in the production of iron and steel is generally included in the following synopsis laid down for the lecturer.

I.—Iron ores, their winning and preparation for smelting in a blast furnace.

II.—The design, construction and principles of the blast furnace, hot-stoves, and blowing engines.

III.—The operation of a blast furnace and the production of pig iron.

IV.—Various grades of pig iron and their suitability for certain specific purposes.

V.—The production of wrought, or malleable iron.

VI.—The production of grey iron castings.

VII.—The production of malleable cast iron, both English and American.

VIII.—The cementation of iron and case hardening.

IX.—The crucible process of manufacturing steel.

X.—The Bessemer steel process.

XI.—The open-hearth, or Siemens acid steel process.

XII.—The open-hearth basic steel process.

XIII.—The electric method of producing steel.

XIV.—Physical and chemical characteristics of various types of steel compared.

XV.—High speed and special alloy steels.

XVI.—Manganese steels.

XVII.—Annealing and heat treating steel.

XVIII.—Micro-structure of steel, and the elements of metallography.

XIX.—Testing of ferrous materials.

XX.—A general summary of the course.

The lectures will be well illustrated with lantern slides and specimens of the material referred to. Mr. Dauncey intends to deliver two lectures a week beginning early in October. The lectures will be given in the Chemistry Building, and there will be a fee of $5 for the course. Further particulars and tickets for the course can be obtained later from the Bursar's office.

## MONTREAL METALLURGICAL ASSOCIATION.

At the beginning of the summer the Council had arranged that the Association should make a series of visits to Montreal works during the summer months. Owing, no doubt, largely to the pre-occupation of the memberhip with munition work, it was found impossible to make these visits, and the first meeting of the session will probably be held at McGill University on the 9th of October. Notices will be sent out to the members in the usual course and further particulars with regard to the Association can be obtained from James Ross, The Milton Hersey Co., Montreal.

## CANADIAN MINING INSTITUTE.

It will be remembered that at the annual meeting held last March in Montreal an Iron and Steel Section was formed for the purpose of furthering the interests of Canadian metallurgists and miners who are interested in the production of iron and steel. All those interested in that subject were invited to send in applications for membership. Dr. Stansfield was appointed to act for the time being as Secretary of the Section, and he intended to visit during the summer a number of places, throughout Canada, where iron and steel is made. His appointment to investigate the possibility of electric smelting of iron ores in British Columbia has prevented him from paying special attention to the Iron and Steel Section, but it is hoped that a programme covering the intended developments of the Section will be ready for publication before long, and that the first general meeting will be held in October or November. It is expected that this meeting will be held at some point in Ontario, possibly in Hamilton. Application forms for membership in this section can be obtained from Dr. Stansfield or from the Secretary of the Institute, 503 Drummond Building, Montreal.

## MESSRS. CANADIAN VICKERS.

The executive of the above firm are to be congratulated upon the manner in which they are living up to their shipbuilding schedule. The 7,000-ton steel cargo steamer Samnanger was launched on August 3rd, and ran her steam trial to Sorel and back on the 18th; on the 15th the s.s. War Earl was handed over to the agents for the British Government, and is now loading. The s.s. War Duchess ran her trials on 25th August, and before this issue of Iron and Steel goes to press four 7,000-ton cargo steamers will have been completed and delivered this season from this yard alone.

## SHORTAGE OF COAL CUTS IRON OUTPUT.

Commenting on the steel situation recently, the Iron Age is concerned about the shortage of coal and coke and the continuance of the labor supply. It says:

"The meeting of the special subcommittee of steel manufacturers with government representatives at Washington on Thursday, August 22, and the calling of a general meeting of steel manufacturers in New York for the following Wednesday, point to the taking of new and important steps to meet the demand for ship, munitions and railroad steel.

"Coal and coke supply still limits pig iron and steel output. The continuance of an adequate labor supply under the new call for fighting men is a seriou problem, and even more grave is the situation caused by the set purpose of labor leaders to bring about union control of the steel industry.

"The situation as to coal and coke and transportation does not measure up to the enlarged requirements of the war. With an average of 360 blast furnaces operating last month, the pig iron output was 110,000 tons a day. With an average of 335 furnaces operating in April, May and June of last year (twenty-five less than in July, this year) the pig iron output for those three months averaged 110,000 tons a day. Thus twenty-five more furnaces are required now to keep the output up to the rate of last year.

"Pig iron allocations in the week have been relatively small. Pending demand includes a round lot wanted for the first 500,000 semi-steel shells to be made for the government.

"For our forces in France 20,000 more cars have been bought. In bridge and building structural work, July bookings were about 210,000 tons or over twice the average of the first six months of the year."

## HOW SLABS ARE HAULED.

### Storage Battery Truck Is Now Employed.

One of the recent devices designed to save man labor is the slab-handling storage battery truck, which is employed at the plant of a steel company in Cleveland to haul heavy pieces of steel from the storage yard to the heating furnaces. The distance approximates five hundred feet. Before electricity was substituted for man-power the slabs were loaded on hand-trucks.

The new truck is similar to the elevating platform truck, except that for its elevating mechanism a tilting platform is provided. This platform is secured to the rear axle by a pivot, being operated by a horizontal ram. By manipulating the ram the platform is moved toward a vertical position and its front edges are lowered.

## ELECTRIC WELDING.

The imperative demands of the war have been responsible for rapid development in innumerable directions but in none is this more marked than in electric welding. It would have been a bold writer who, only a few years ago, had ventured to suggest welding for any of the hundred and one purposes in which its application is to-day an accomplished fact. This statement receives its strongest corroboration from the knowledge that the Technical Committee of Lloyds Register have, after exhaustive experiments, decided to allow welding in ship construction. It is safe to assume that satisfactory results have been obtained otherwise this concession would never have been granted by this most conservative institution. In keeping with the general speeding up policy of the U. S. Shipping Board a special welding research sub-committee has been apointed which includes the names of most of the leading metallurgical authorities. At present electric welding is being applied to the accessories and in this direction an enormous amount of time is being saved in ship construction, and the results obtained are giving every satisfaction.

Experimental work on the welding of plates is constantly being carried out and a rivetless barge has been completed and handed over to Lloyd's representative to be tested to complete destruction. Upon the result of this test depends whether the vessel with welded plates will or will not be accepted for insurance. In the latter case it is probably the U. S. Government will continue to use welding in a modified way and create an insurance fund for themselves. The International Equipment Co., of Montreal, induced the welding expert of The United States' Shipping Board to visit Montreal and on Friday August 30th he delivered a most interesting and instructive lecture in the Rose Room of the Windsor Hotel. The lecturer prefaced his remarks by stating that he would deal with the "Progress of Electric Welding in Ship Construction" and show how the process was expediting production and the operations would be fully illustrated by lantern slides and blackboard sketches. In tensile testing it was usual to take two test pieces from an unwelded plate and to adopt the mean of the figure obtained as a standard. It was explained that two classes of weld would be dealt with in all such tests, one in which the extraneous metal was left on as it came from the welders hands, and the other in which the weld had been planed or machined off. In the former case the cross-section through the weld is slightly larger than through the original plate. When the committee publishes its report it will be interesting to compare the physical characteristics of welded and unwelded pieces; will the ultimate be materially lowered and how will elongation and reduction of area figures appear; and will most of the fractures occur in the welds. Whilst not wishing to prejudge the operation it seems reasonable to suppose that the intensive local heating will exert a prejudicial influence upon the physical strength, but whether this will be too serious remains to be seen. With men like Dr. Merica and Dr. Howe devoting close attention to the subject it is certain definite results will be obtained over a long series of experiments, and if, as anticipated, some unknown embrittling influence is to be feared their researches will enlighten the subject. The question of chemical composition will have to be fully studied for it may well be that material with a high carbon and low silicon content will yield the best

welding results. Again will it be found that electric furnace steel, owing to low exygen, will give more satisfactory welding than open-hearth material. It is quite possible that limitations will arise when efforts are made to weld long seams, it may be that some slight defect could induce creeping failure in the actual weld, should this condition develope the proces might still be eminently satisfactory for short joints although not acceptable for longer work. In a later issue we hope to have detailed information for our readers and shall endeavour to secure actual figures relating to tests of various kinds, to the A-C or D-C power to be selected, to heat control, efficiency and comparative costs. The whole question is one teeming with unknown factors and it is to be sincerely hoped that, notwithstanding the abnormal pressure of war time conditions, time will be found to finally reach conclusions upon the various points already enumerated. To metallurgists and those engaged in the fabrication of ships the problem is one of the utmost importance and interest, and the International Equipment Company are to be congratulated upon the fact that their President—Mr. E. G. Jackson—was able to induce Mr. Holslag to visit Montreal and to lecture upon the Progress of Electric Welding in Ship Construction.

## STEEL AND COPPER SCRAP WORTH MILLIONS RECOVERED.

No more striking example of the importance of conservation could be given than that contained in a report of the Imperial Munitions Board. In making the turnings on the copper driving bands of shells produced in Canada for the British Ministry of Munitions a large quantity of copper scrap is accumulated. This is refined and cast into ingots. Up to date 10,000 tons of copper has thus been reclaimel, representing a value of approximately $5,000,000.

Steel scrap is also being continuously recovered in large quantities, the present annual value of which is approximately $5,000,000.

British Forgings, Limited, a subsidiary organization of the board, operates one plant, which is the largest electric steel plant in the world, where the steel scrap accumulation collected from hundreds of munition factories in Canada is converted by the electrical process into ingots and forgings.

Operations commenced in July, 1917, and the present monthly capacity of the plant is about 5,000 tons of shell steel. Up to May 31, 900,000 6-inch shell forgings had been produced, in addition to 69,500 9.2-inch shell forgings.

Burnett & Crampton is a new firm of engineers and iron founders which has recently been established at Rigaud, Que. They have a very well equipped shop, capable of handling eight tons per day with a machine shop, pattern shop and blacksmith's outfit. Mr. Burnett was the electrical engineer for the Canada Cement Co., Ltd., and also has had considerable mechanical foundry experience. Mr. P. P. Crampton is very well known to the Iron and Steel industry through his previous connection with the Hull Iron & Steel Foundries, Ltd.

## SAVES 9,000 GALLONS OF OIL PER WEEK.

W. A. Buchanan, Sales Manager of the Canadian Incinerator Company, Limited, Traders Bank Building, Toronto, whose "Efficiency" furnaces, oil burners and pre-heating system are effecting surprising economy in oil and labor, has recently closed contracts with the Davie Ship Building and Repair Company, Levis, Que., and the British-American Ship Building Company, Welland, Ont.

The "Efficiency" equipment is already in use in Toronto in the Canada Metal Company, John Inglis Company, Cluff Ammunition Company and British Forge, Limited.

As a concrete example, one Toronto concern is saving 9,000 gallons of oil per week, and is getting cleaner and better production than with their old system of heat-treating.

## CONCRETE SHIPS CONTAIN FORTY-TWO AND ONE-HALF PER CENT STEEL.

It has been figured out that in ships built of reinforced concrete the weight of steel is about 42½ per cent of that in a steel ship. This estimate is based on a ship 205 feet long, 2 feet beam and 19½ feet draft.

## INSTALLS FURNACE.

The Industrial Electric Furnace Co., Chicago, makers of the Snyder electric furnace, is installing a 5-ton furnace in the plant of the Zimmerman Steel Co., Bettendorf, Ia. It is a three-phase furnace, designed for acid operation, and will be used for general work. The furnace will replace a converter.

## SAFETY DEVICE FOR BREAKING DRILLS.

The Ford Motor Co. is employing a simple device to protect the men employed in breaking up hard drills, or other brittle or high-speed scrap metal. As these drills are made of two kinds of steel, high-speed for the lower portion and a softer grade for the shank, it is desirable to keep the two kinds of steel separate.

The device used consists of a boxlike section with a front member of ¾-in. metal having holes of various diameters drilled in it. In use this section is placed in a vise and the drills which are to be broken put in the holes. When a piece of pipe is slipped over the projecting end and a slight pressure applied, the drill is broken, one half going down through the pipe and falling into a box or other receptacle at the operator's feet, while the other part is pulled through and dropped into another box. In this way, any likelihood of injury, due to flying bits of steel following the fracture, is found to be eliminated.

A cupola of given size (interior diameter) should be worked to deliver a certain quantity of iron within a given time, which should under no circumstances be altered. This statement is based on the fact that there is really only one correct system of getting iron of the right quality from one particular cupola, i.e., one volume and velocity of blast and one arrangement and weight of fuel and iron to bring the iron charges directly into the melting zone at the right time and under the right conditions.

# Iron, Carbon, and Phosphorus

By DR. J. E. STEAD, F.R.S., Vice-President.
Iron and Steel Institute.

A paper read at the Annual Meeting in London in May, 1918.

This short paper may be taken as Part II. of the paper read before this Institute in 1915[1] and will be treated in two sections:

Section I.—The effect of introducing carbon, by cementation, into homogeneous solid solutions of iron and phosphorus.

Section II.—The temperature ranges in which free phosphide of iron passes in and out of solid solution in iron.

### Section I.

It has been proved that when alloys of iron, carbon, and phosphorus are heated to the point of incipient fusion, the phosphorus and carbon become concentrated in the part that first becomes liquid. On the other hand, it is well known that if the same alloys after complete fusion are gradually allowed to solidify, the last portion to become solid contains much more carbon and phosphorus than the parts which first solidified.

It has been shown by Professor Arnold and others that alloys containing traces up to 1.36 per cent phosphorus and practically no carbon, when allowed slowly to solidify and cool, contain all the phosphorus in solid solution, and that if the carbon is gradually increased in the liquid metal, after solidification it contains more and more free phosphide of iron, and that when a maximum amount of carbon is present the greater part of the phosphide exists in the free state in a eutectic mixture. It follows, of course, that if the metal contains just sufficient carbon short of that required to lead to the separation of a eutectic, the last portion to freeze may be a saturated solution containing about 2 per cent phosphorus and will contain no phosphide in the free state.

It has further been proved that when a steel of medium carbon content becomes completely solid and is then slowly cooled the portions richest in phosphorus are quite free from carbon, although it is known that the two elements must have been in association at the point of solidification of the steel. The reason for this appears to be that the solid solution pressure of carbide and phosphide together is considerable, and that as the carbide is very mobile, whilst phosphide is less so, the carbide simply moves into the surrounding metal where the solution pressure is feeble—that is to say, into and near to the primary crystals, which first fell out of solution, and which contain less phosphides and carbides. As cooling progresses, the carbide in solid solution steadily flows towards the purer portions, concentrates there, and finally separates as free carbide of iron ($Fe_3C$) in pearlite.

The phosphide, which, like the carbon, is still in tension in the areas vacated by the carbon, slowly flows outwards into the regions where the internal tension is lower, but, as the temperature falls, its power to move becomes less and less, and at about 800° C. becomes exceedingly sluggish, and at 500° C. it is practically stagnant.

[1] Journal of the Iron and Steel Institute, 1915, No. I, p. 140.

### Distribution of Phosphorus in a Cast Alloy.

This note, as will be seen later, shows how wonderfully excursive phosphide in solid solution in iron really is. It leads one to believe that when the relations of iron, iron phosphide, and carbon are better understood, it may be possible to control the effect of phosphorus on the physical properties of steel.

The fact that prominent metallurgists refer to phosphorus as treacherous is clear proof that the reason for its variable effect is not known. But for the knowledge gained by years of research on the influence of carbon on iron, that element probably would be considered even more treacherous than phosphorus. We have gained knowledge, and now know how to control the effect of carbon.

The series of six photographs (Plate I.) of an alloy in the cast condition, containing about 0.3 per cent carbon and 0.3 per cent phosphorus, after etching by different reagents, clearly shows where the phosphorus is concentrated. The first three were taken from the same area, but were etched in different ways:

No. 1 was etched by alcoholic nitric acid, and shows simply the pearlite areas (dark) and ferrite (white).

No. 2 is the same as No. 1, after an attack by the author's cupric reagent, but only the phospho-ferrite and the carbide of the pearlite remain white. The ferrite of the pearlite and the ferrite surrounding the pearlite areas have been stained by the cupric reagent, which is an indication of relatively low phosphorus.

No. 3. After repolishing and attacking by picric acid in water, the parts rich in phosphorus are stained quite black, but do not correspond exactly with the white areas in No. 2; they are included in it, but are very rich in phosphorus.

No. 4 is a part of the same steel; it was heated to 960° C. and quenched in water, and etched with nitric acid in alcohol. It shows that the carbon has not diffused into that part of the ferrite which is highest in phosphorus, but has invaded the part containing less.

No. 5 is the same area as No. 4, after repolishing and etching with a cupric reagent. It shows that although the carbon has diffused into the parts lower in phosphorus, the phosphorus has not moved.

No. 6 is the same area as Nos. 4 and 5, after repolishing and etching with aqueous picric acid solution. The parts of the ferrite richest in phosphorus are darkened, and on comparing these darkened areas with the white areas in No. 4 it will be noticed that they correspond exactly in shape and volume.

By heating to 960° C. the carbon has been forced to invade the parts of the ferrite less phosphorised, but on slow cooling it returns to the parts still lower in phosphorus, leaving them free from carbon. If the cooling is effected in about five minutes, the pearlite does not concentrate in the original position, but remains distributed in small separate grains in the areas proved

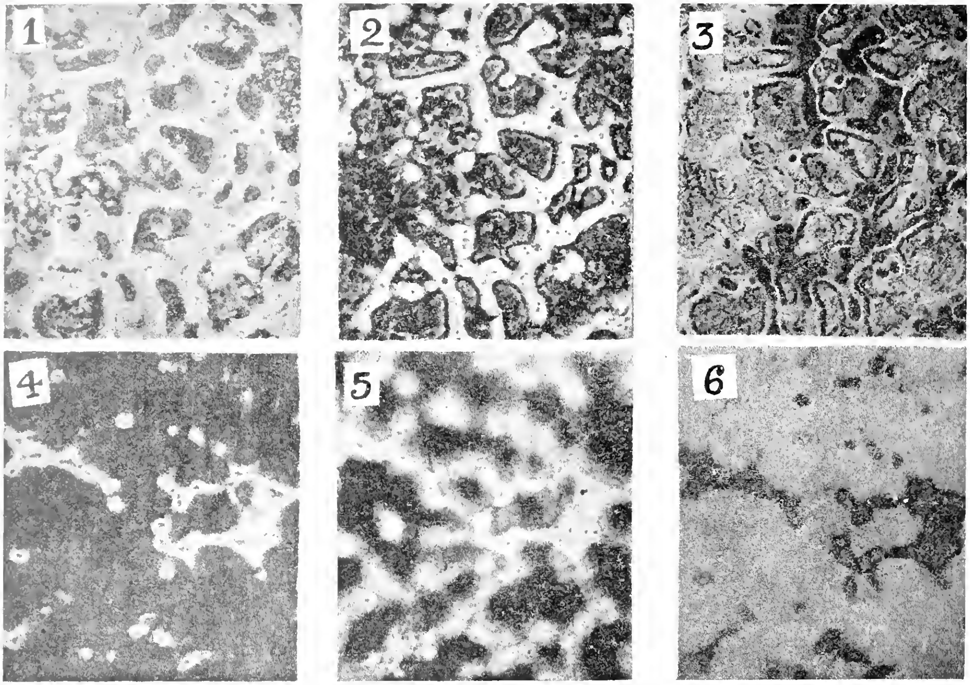



PLATE I.

to be lower in phosphorus, which includes the areas occupied by the original pearlite and the ferrite envelopes. When, however, the alloy is heated to 1200° C. and slowly cooled to 500° C. in a period of three to four days, the phosphorus is found to be more homogeneously distributed, and the cold steel then has a structure approximating to that of a normal steel containing the same amount of carbon. (See note on Inclusions in Steel.) The long heating at above 1200° C. allows the two elements time to become interdiffused, and in cooling no separation is effected. All rolled steels containing phosphorus ghost-lines, after long heating to above 1200° C., are homogeneous, and phosphorus lines no longer appear on etching the cold steel.

**Effect of Introducing Carbon by Cementation.**

Judging from the foregoing remarks, it would appear that the solution pressure of the carbon very greatly increases with the temperature, and that phosphide of iron, although less rapid in its movement than carbon, is very excursive; indeed, when it is irregularly distributed in iron, the phosphide in the parts richest in phosphorus at high temperatures diffuses into the parts containing less, and in time perfect homogeneity is produced.

Now on these bases it seemed certain, if an alloy containing phosphorus homogeneously distributed is carburized at a high temperature, that as the carbon passes into solid solution the internal tension will be increased, for, to the tension of the phophorus will be added that of the entering carbon. Under such a condition one would expect that as the carbon enters, the phosphorus would be forced to move out of the areas invaded by the carbon and become concentrated in the surrounding metal, and that this concentration would proceed until the increased tension of the phosphide in solid solution balanced the tension of the carbide in solid solution. Theoretically then, if the temperature is below that of the formation point of the ternary eutectic Fe-C-P, eventually no more carbon could enter into solid solution, and that would be when the tension in the territory held by the carbon is equal to that in the parts where the phosphide is concentrated. To what extent the $Fe_3P$ can be concentrated in that way is not known, but it is probable it would approach the point of saturation, or 14 per cent.=2 per cent. phosphorus.

To determine whether this hypothesis was correct or not, the following experiment was made:

An alloy containing about 0.5 per cent phosphorus in homogeneous solid solution, but quite free from carbon, in the form of a short bar 1½ inch by 1 inch by ½ inch, was sawn vertically through its centre, thus making two bars 1½ inch by ½ inch by ½ inch. The sawn faces were placed in juxtaposition, and the lower ends placed on a bed of charcoal at the bottom of a plumbago crucible. They were surrounded and covered by sand and a lid luted on to the crucible. The crucible, with contents, was then placed in a muffle furnace having a temperature of 960° C., and retained in that positien for six hours, and was then heated to 1150° for one hour in a separate furnace. The crucible was removed and one of the bars was quenched in cold water, the other was allowed to cool down slowly in the crucible. By this means one ob-

tained in the quenched bar martensite areas corresponding exactly with parts into which carbon had penetrated, whilst in the bar slowly cooled one obtained pearlite islands in ferrite, into which the diffused carbides had condensed or segregated from the parts invaded by it.

The juxtaposed faces of the bars were polished and etched by various reagents, and protographed. The photo prints are shown in Plate II.

No. 7 is a photograph of the bar itself after a strong attack by a cupric reagent. Note that the carburized end is dark, while the other is light.

No. 8 represents the structure of the specimen quenched from 1150° C. at a point where there was only about 0.20 per cent carbon. Etched with acid.

No. 9 is the same area as No. 10 etched by the cupric reagent.

No. 10 represents the slowly cooled bar at an area corresponding to No. 8 etched by acid, which left the carbide areas as pearlite (dark) on a white ground.

No. 10a represents the most carburized part of the cemented bar etched by acid, after quenching from 1150° C. ×100.

These illustrations are most instructive and prove the correctness of the hypotheses advanced, but are also suggestive as to the way in which the carbon enters the central portions of the bars.

On examining the photographs Nos. 8 and 9, it will be noticed that in each one the dark areas are islands quite isolated from one another, and are completely surrounded by ferrite. It is obvious then that the carbon has not entered the metal directly from the charcoal cementing material, for if it had there would have been a continuous track of martensite leading from the exterior to the interior of the quenched bar.

A son of the author (the late Lt. J. K. Stead), in a research he made on the question of carburization, found that if pure iron or soft steels were covered with a porous layer of magnesia, lime, or asbestos, and were cemented alongside duplicates of the same metals with bare surfaces under identical conditions, the carburization was equal in each set of cases, yet in one the charcoal was in direct contact, while in the others the iron was separated from it by porous coverings. Obviously, then, the carbon did not combine directly with the metal.

Evidence is conclusive that metals at high temperatures are quite porous to gas (carbon monoxide), and it is this gas continuously produced in the cementation furnace that effects carburization: indeed, it is quite easy to carburize iron by carbon monoxide alone without the presence of any solid carbon. A cementa-

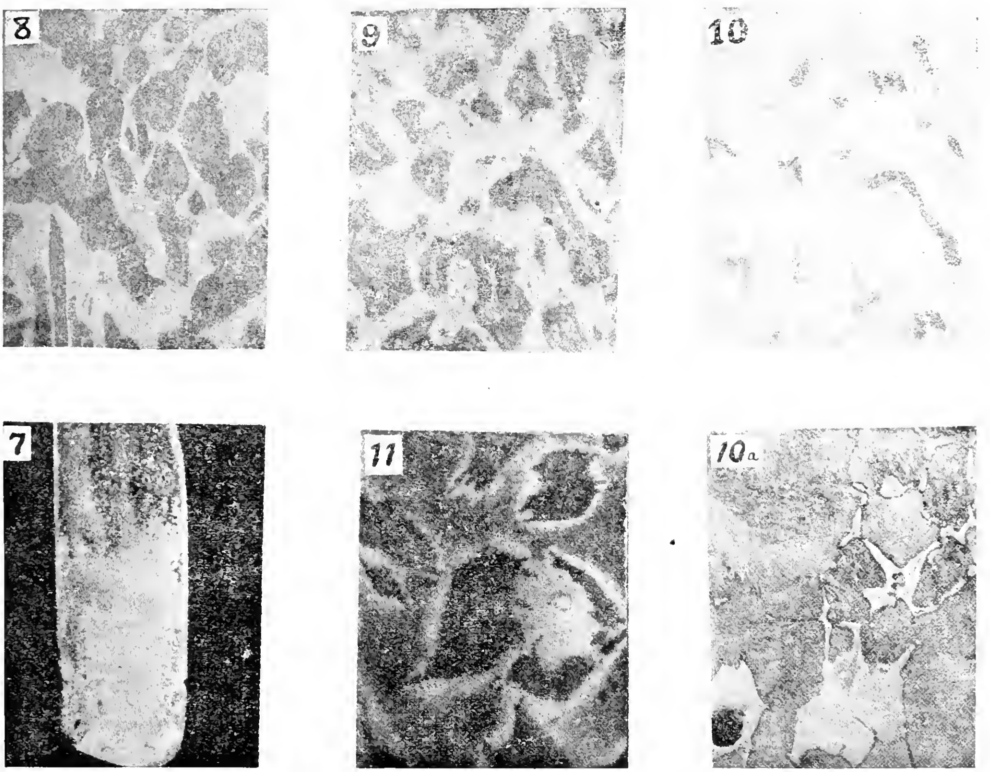



PLATE II.

tion furnace, therefore, may be considered simply as a carbon monoxide gas producer, and one in which the carbonic acid, produced in the carburized metal after it diffuses out, is regenerated. The reactions are, of course, well known and may be briefly described.

Carbon monoxide is primarily produced by the combination of oxygen of the air mechanically associated with the charcoal and the carbon of the charcoal. This carbon monoxide penetrates the metal, and gives up a small part of the carbon to the iron, but the oxygen of the decomposed carbon monoxide combines with a portion of the excess carbon monoxide gas, forming carbon dioxide. The carbon dioxide tends to oxidize carbon at high temperatures, and can only be formed in such proportions as to establish equilibrium with the remaining carbon monoxide so as to produce an inert mixture. When this point is arrived at, the mixture diffuses out of the metal and comes into contact with the charcoal, which at once removes half the oxygen from the carbon dioxide, producing in its place double its volume of carbon monoxide. The cycle is then complete and is continuously repeated.

When pure iron is cemented, as a rule the carburized areas are continuous when the metal is in a heated state, the parts nearest the outside being always richest in carbon. On quenching such carburized iron directly it leaves the furnace, the martensite forms an almost connected layer from the outside to the extreme point to which the carbon has penetrated.

There can be little doubt that the greater solution pressure of the carbide on the outer layers leads to diffusion towards the centre of the bars, for on heating superficially carburized iron in vacuum to a high temperature, the carbide does diffuse inwards.

Although carburization of iron is effected by charcoal in the manner described, it must not be assumed that iron and carbon cannot directly combine without a gaseous vehicle, for Sir W. Roberts-Austen long ago obtained direct union by heating a diamond in vacuo in contact with iron.

It is well known also that free graphite locked up in grey pig iron combines directly with the iron surrounding it on heating to a point short of fusion.

An interesting experiment with a piece of a bear from a Wigan blast-furnace demonstrated the same thing. The specimen contained more than 1 per cent of phosphorus in solid solution, and spheroidal segregations of graphite distributed at wide intervals, and only traces of pearlite. A portion of this was heated to about 1300° C. for about ten minutes; it was then quenched at once in water. On sectioning the quenched material, polishing and etching with an acid, and then with a cupric reagent, the evidence was conclusive that not only had the carbon combined directly with the iron, but had diffused into the surrounding metal, and in doing so had caused the phosphide to pass out of solid solution and unite with some of the carbide to form the liquid ternary eutectic which first appeared at the crystal junctions and later as liquid globules, which by coalescence with other globules eventually reached the junctions of the iron carbon crystals, and flowed along these back into the place originally occupied by the graphite.

Having explained the general principles underlying normal carburization, return must be made to the cemented phosphoretic iron. In this, excepting at the surface most highly carburized, the penetration is not continuous, and in the centre of the quenched bar, as before stated, the carburized portions are completely surrounded by ferrite. One can only advance hypotheses to account for this, and assume that the metal was not absolutely homogeneous, and that carbon was first deposited in the portions containing a slight excess of iron or a slightly less amount of phosphorus. From the very start, as was proved, the carburized areas are isolated even where the metal was in contact with the charcoal, and these develop more or less radially with the progress of cementing. Proof that as the carbon enters it causes the phosphorus to diffuse away from it is given in photo No. 11, of a few minute areas, highly magnified, where carburization had just commenced. The specimen was quenched and etched first with acid and then with a cupric reagent. The dark martensite is surrounded by a white envelope which is higher in phosphorus than the metal exterior to it. A part of the phosphorus has been forced into that position by the dominating solution pressure of the carbon. That the phosphorus is generally concentrated in the ferrite, owing to carbon penetration, is proved by the photograph of the whole bar after it was polished and then etched with copper solution, for the end where carbon penetrated is only slightly stained, while the other end is almost dark, due to a greater deposit of copper. Copper is only deposited on the parts where phosphide in solid solution is small, refusing, in the same period of time, to deposit where it is greater.

The evidence that the areas invaded by the carbon surrounding the pearlite are very low in phosphorus is given in the photo No. 8 of the annealed specimen after etching with the cupric reagent. It will be noticed that the areas of martensite in the corresponding quenched specimen have about the same superficial area as the half-tone envelopes and the pearlite together of the slowly cooled metal.

It is evident that once the carbon has entered at several independent adjacent points, the phosphorus in the surrounding ferrite is increased and the solution pressure or tension, being also increased, must tend to check the ability for external carbon to enter it. That such is the case was proved by cementing thin plates of metal of the same size and thickness but containing varying proportions of phosphorus. The results were as follows:

| | Carbon absorbed. Per Cent. |
|---|---|
| Iron alloyed with 1.2 per cent phosphorus.. | 0.53 |
| Iron alloyed with 0.6 per cent phosphorus.. | 0.60 |
| Pure electrolytic iron—nil................. | 0.94 |

The carbons were determined by the color method, as weights of the minute plates were insufficient to make combustion analyses, and therefore must be regarded as relative only.

**Summaries and Conclusions.**

1. It has been proved that the pearlite areas in medium carbon phosphoretic steel castings, and the ferrite immediately enveloping these areas, contain much less phosphorus than the ferrite exterior to them.

2. Conclusive proof has been advanced that as carbon enters into phosphorized iron by cementation, the phosphide of iron diffuses out of the areas invaded by the carbon, and is concentrated in solid solution in the surrounding ferrite, and that this concentration increases as the carbon increases, probably at tempera-

tures just short of incipient fusion, until the ferrite becomes saturated with the phosphide, and, when that point is reached, although carbon may continue to increase in the carburized portion none will enter the saturated solution of phosphide.

3. The amount of carbon capable of passing into iron by cementation at any given temperature, short of the ternary eutectic formation point, depends upon the amount of phosphorus present in the iron and varies inversely with the phosphorus.

If the temperature of the cementation furnace exceeds the formation point of the liquid ternary eutectic, the internal tension in the ferrite rich in phosphorus, due to the continued increasing external tension of the invading carbon, at last becomes so great that the phosphide is forced out of solid solution in the very centre of the ferrite, forming a eutectic liquid.

5. It is confirmed that graphite can carburize iron without the interposition of any gaseous vehicle, and that the carbon, in diffusing from graphite nuclei bedded in iron containing phosphide in solid solution, behaves in a similar way to carbon from carbon monoxide: it concentrates the phosphide in the ferrite and eventually at 1200° to 1300° C. throws it out of the solid into the liquid solution, producing the ternary eutectic Fe–C–P, which appears in the globular form and as intercrystalline envelopes, and finally liquates out of the metal.

6. The research opens the door for more investigation. The specimens experimented upon were very high in phosphorus, much higher than is permissible in any steel. It is proposed to make further trials with steels containing variable quantities of that element within the limits of 0.12 per cent and 0.02 per cent, when associated with between 0.1 per cent and 1 per cent carbon.

SECTION II.

### The Temperature Ranges at Which Iron Phosphide Passes In and Out of Solid Solution in Iron.

When this investigation commenced it was thought that the ranges of temperature at which phosphide of iron ($Fe_3P$) passed in and out of solid solution in iron would be as readily determined as the critical ranges at which carbide of iron passes in and out of pure iron, but instead it was discovered that, owing to the more inert character of the phosphide, such was not the case. It was found that years of careful research would be necessary before complete knowledge could be obtained.

The records which follow must be regarded as the result of a reconnaisance and scouting expedition into an almost entirely new, unexplored country, but nevertheless contains sufficient evidence to enable anyone to more systematically carry on future work. The importance of what has been done, however, will be recognized when it is seen that there are indications that similar laws govern the solid solution and dissolution of solids in solids as those which govern the solution and dissolution of crystalline salts in liquids.

The illustrations, with descriptions, enable one to see at once the proofs of solution and dissolution. This has only been possible because during the past few years greatly improved methods of etching and staining the complex mixtures have been evolved.

What little work that has been done in the past on the crystallization of $Fe_3P$ from solid solution is recorded in various papers by the author, and the first indication or evidence of the temperature at which free phosphide could be induced so to crystallize was published in the Journal of the Iron and Steel Institute in 1890, in which it was noted that on exceedingly slow cooling from above 1200° C. of an alloy containing about 2 per cent phosphorus and 0.12 per cent carbon, free phosphide of iron separated out between some of the cleavages of the iron crystals. The alloy in question was made by melting puddled iron with phosphorus in a clay crucible. After melting, the crucible and contents were allowed to cool slowly in the fire; the time of cooling to 500° C. was estimated at about six hours. As no free independent phosphide of iron ($Fe_3P$) crystals were present in the original alloy, it was assumed that the time occupied in cooling through the critical range in the crucible furnace was not sufficient to admit of the crystallization of that body from solid solution. On reheating to between 1200° and 1300° C. in a 3-ton ladle of molten blast-furnace slag and allowing the alloy and the slag to cool down together in about four or five days, free crystals appeared—proof that long cooling through the critical range, whatever that may be, was sufficient to admit of some of the phosphide of iron crystallizing out. Particulars are now given of the most recent investigations in that connection.

### Alloys Used in Experiments.

A series of alloys was selected, on which to experiment, including:

Series I.—A decarburized alloy from a Cleveland blast-furnace bear referred to in the accompanying paper on Blast-Furnace Bears, which, although variable in different parts, contained free phosphide in envelopes round the crystals of iron and free $Fe_3P$ in the body of the metal. The analyses varied between:

| | 1. Per Cent. | 2. Per Cent. |
|---|---|---|
| Phosphorus in solid solution | 0.50 | 0.623 |
| Phosphorus in the free phosphide | 0.40 | 0.883 |
| Total | 0.90 | 1.506 |

Series II.—A Mexican meteorite containing rhabdite or free phosphide crystals.

Series III.—Alloy of iron and phosphorus made by adding phosphorus to white-hot puddled bar in a clay crucible. It contained:

| | Per Cent. |
|---|---|
| Phosphorus in solid solution | 1.16 |
| Phosphorus in eutectic | 0.04 |
| Total | 1.20 |
| Carbon | 0.12 |

Series IV.—A series of alloys containing between 0.4 per cent and 2.2 per cent phosphorus made by the thermit process. These contained rather variable amounts of silcon, aluminium, etc., approximating on an average to:

| | Per Cent. |
|---|---|
| Carbon | 0.05 |
| Manganese | 0.10 |
| Sulphur | 0.04 |

| | |
|---|---|
| Silicon | 0.15 |
| Aluminium | 0.12 |
| Phosphorus | 0.4 to 2.2 |

Series V. Portions of the Cleveland decarburized bear free from independent phosphide of iron ($Fe_3P$) containing only traces of carbon and between 0.5 per cent and 0.60 per cent phosphorus in solid solution.

SERIES I.

### Temperature at Which the Phosphide of Iron Passes Into Solid Solution.

The first trials were made on the decarburized bear referred to, containing:

| | Per Cent. |
|---|---|
| Phosphorus as free phosphide of iron ($Fe_3P$). | 0.70 |
| Phosphorus in solid solution | 0.55 |
| Total phosphorus | 1.25 |

After making a large number of trials by heating at various temperatures over long periods extending from six to twenty-eight hours, it was found that whilst none passed into solution at 800° C., at 850° C. solution commenced. It may be expected, therefore, that with a solvent containing about 0.5 per cent phosphorus, phosphide commences to dissolve at some point between 800° and 850° C.

On heating to 960° C. solution proceeds with considerable rapidity.

On examining Plate IV. the progress of solution will be seen. In five minutes it is considerable, in fifteen minutes it is nearly complete.

On long heating at 1000° C. the diffusion is perfect and the alloy homogeneous, for sections of the metal after polishing and etching with a cupric reagent show no dark and light-colored places.

SERIES II.

In the last series the solvent metal contained a considerable quantity of phosphide in solid solution, and it was naturally believed that it would not dissolve phosphide so readily as pure iron free from phosphorus.

Having a specimen of a Mexican meteorite containing free crystals of iron nickel phosphide, or rhabdite, containing:

| | Per Cent. |
|---|---|
| Phosphorus in solid solution | 0.21 |
| Phosphorus in phosphides | 0.06 |

trials were made with it to find out at what temperature the crystals began to dissolve.

Of course there is objection to using a nickel iron alloy containing about 5 per cent nickel, and rhabdite, which contains much more nickel than the matrix, and one could not infer that it would behave in the same way as an alloy free from nickel. Whether that is so or not, it was of interest to find out how it did behave. Without going into detail, it is sufficient to say that the rhabdite began to dissolve at about 600° C. on heating for twelve hours, proving that solution begins at a relatively low temperature as compared with the iron alloy. As the heat is raised solution is, of course, very pronounced and rapid.

There were certain phenomena connected with the heating of this alloy which cannot at present be explained. It is reserved for further investigation.

Not having any pure iron with free phosphide of iron crystals in it, and no phosphide in solid solution, an attempt was made to make a mechanical mixture of iron and phosphide crystals. For this purpose a minute hole was bored into a piece of Armco iron containinfi 99.8 per cent iron. A few crystals of iron phosphide were placed into the borehole. (The iron phosphide crystals were obtained from the Cleveland bear already referred to.) A plug of the same iron was then driven into the hole, and the bar was flattened cold under a steam forge hammer, which, of course, forced in the sides of the hole against the phosphide. The bar was then heated to 700° C. for three hours, after which it was sectioned and examined. The sides had not welded together where they came into contact, but at points there was distinct evidence that the phosphide had commenced to dissolve in the iron. This experiment is to be repeated and the period of heating prolonged at a lower temperature. It proves, however, that while the same phosphide does not dissolve in iron partially saturated with phosphide in solution, it does dissolve in iron free from phosphorus at 700° C.

SERIES III.

### To determine at what Temperature Phosphide falls out of Solution.

In this set of trials a bar ½ inch square and 4 inches in length was bedded in mill scale contained in a porcelain tube closed at one end. The closed end was inserted through a hole in the side of a muffle furnace which was heated to a temperature of 1000° C. each day during six hours. The hot end of the bar was actually heated to the point at which silver wire just melts, while the other end, which protruded out of the muffle furnace, never attained a temperature above 500° C. It was heated intermittently for sixty hours and then removed from the furnace and examined. The temperature at each point along the bar, when at maximum temperature, was taken at intervals and the positions noted. The bar was ground down on one side, and, after polishing, was etched and examined under the microscope. Before describing the observations it is necessary to explain that, as the bar contained some carbon, it was thought desirable to remove it if possible, at least in the parts where it was heated above 800° C., hence the object of bedding it in mill scale.

Like all cast alloys of iron and phosphorus, the phosphorus was not uniformly distributed. It contained traces of the eutectic Fe–P, and at places adjoining these, the alloy must have been a saturated solution of iron and phosphide containing about 2 per cent phosphorus. As it contained patches of pearlite at intervals bedded in the parts containing least phosphorus, from actual trial it is known that the territory covered by this pearlite contained much less phosphorus than the average in the whole metal. There were, in fact, parts very rich, parts less rich, and parts poor in that element, and therefore in the one alloy a series of three distinct alloys.

On examination after heating it was found that in

the parts most highly charged with phosphorus, free crystals of iron phosphide ($Fe_3P$) were present at all places where the temperature exceeded 660° C. up to 900° C. The crystals were exceedingly minute where they had formed at the lower temperature, but increased in size as the temperature rose, and were at a maximum at 900° C. At about 800° to 850° C. the amount crystallized out was at a maximum, but at 800° C. no crystals could be detected in areas originally occupied by the pearlite, which were now completely decarburized by the mill scale. These areas, of course, contained the least phosphide in solid solution. Where the metal had been heated at 900° C. only in the metal adjoining the eutectic films were there any free crystals, and at 960° C. there were none. The metal at that temperature had become a homogeneous solid solution. There were no eutectic films, for, presumably, the phosphide had diffused out of them and passed into solid solution at such a high temperature as 960° C.

These observations show clearly that the temperature at which phosphide of iron ($Fe_3P$) falls out of solid solution depends upon the amount present.

### SERIES IV.

In this series the thermit metals were employed, and, in passing, it is important to note the original structures of the cast alloys.

All of them when etched with a cupric reagent became rapidly colored on the parts which had first fallen out of solution. The dark markings were in the form of octahedral skeletons very clearly marked on polished cleavage faces. In addition to these, in the alloys containing between 0.9 per cent and 2.2 per cent phosphorus there were present trains of the binary eutectic of iron and phosphorus on all the sides of the dark-stained primary crystallites.

They were all heated in a muffle furnace for six hours at 1000° C. and then re-examined. As was expected, such treatment led to the diffusion of phosphide and iron. The primary crystallites no longer were in evidence, and excepting in the alloys containing more than 2 per cent phosphorus, the eutectic had also vanished and the metals had become homogeneous solid solutions.

What is most remarkable is that on re-heating the alloy containing 2.2% phosphorus to 1050° C. for a short time in an attempt to get more of the eutectic dissolved, and then for a longer time at between 960° and 1000° C., a crop of minute iron phosphide ($Fe_3P$) crystals appeared. Possibly at the higher temperature the iron had become supersaturated and on heating to the lower temperature the excess fell out of solution. (See Plate III., No. 17.)

On reheating this same specimen for six hours at 800° to 840° C. the crystallites developed to a considerable extent, as will be seen in photo No. 18, Plate III.

Another specimen, containing close on 2 per cent phosphorus, heated to 1000° C. had no free crystals, but contained some undissolved eutectic. On heating at 820° to 840° C. for six hours new crystals developed freely. No. 19, Plate III. Probably this would have

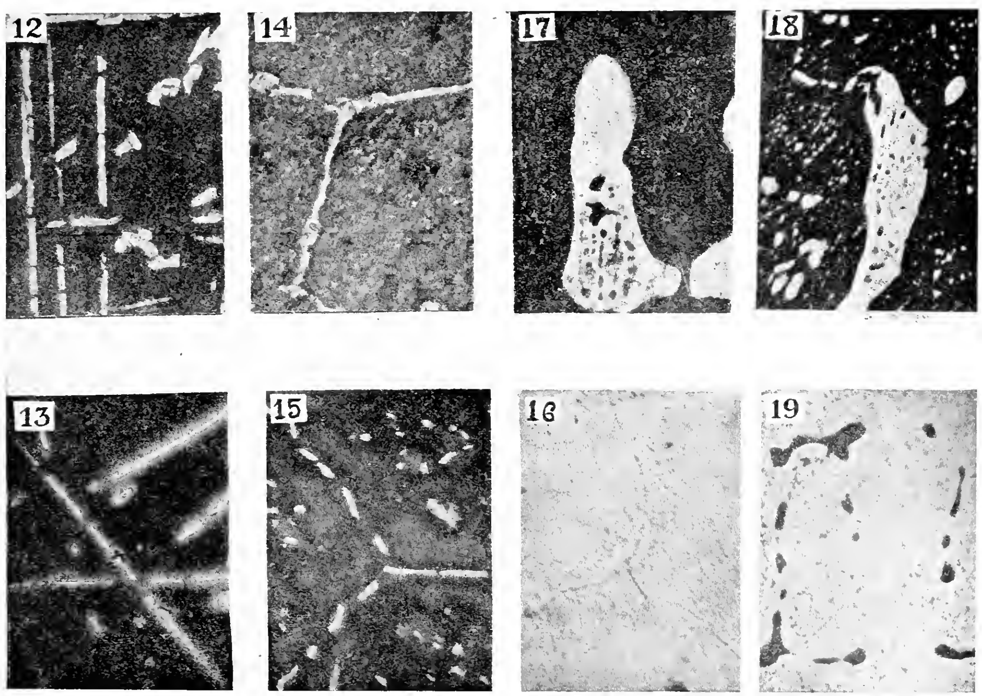



PLATE III.

yielded crystals at 900° to 960° C., but the experiment was not made owing to want of time.

SERIES V.

In this series sections were used cut through three columnar crystals of the Cleveland decarburized bear. One containing a total of 1.25 per cent phosphorus was heated to 960° C. for ten minutes, when it was found that practically all the free phosphide had dissolved, but was concentrated in solid solution around the traces of undissolved phosphide. It was then heated for several hours at 780° to 800° C., after which treatment it was proved that some phosphide had recrystallized round the original traces of the free phosphide. The specimens before and after the treatment are shown on Plate III, Nos. 14 and 15.

Another section was heated to 1000° to 1050° C. to produce a homogeneous alloy. It was then reheated for six hours at 820° to 840° C. Fine crystals formed at the junctions of the crystals and near to the junctions. The evidence here is that when pre-existing free phosphide exists, on heating to a temperature favorable for crystallization the phosphide is primarily attracted to it.

It will be noticed in photos Nos. 14, 15, 17, 18, 19 that round about the larger masses of free iron phosphide there are borders containing practically no crystals, presumably because the enveloping layers of phosphide had been first formed and had attracted the phosphide from the metal near them before the temperature fell low enough for the crystals to form in the body of the metal.

## Analogy Between Liquid and Solid Solution and General Conclusions.

Iron phosphide is a chemical salt, for, in its formation, when iron and phosphorus are brought together at a temperature of 1000° C., or above, chemical union is effected and is accompanied by considerable rise of temperature. There seems little doubt that it retains its identity after it dissolves in solid iron.

The following facts relating to one of the most simple salts—sodium chloride in water—will enable one to compare them with the evidence advanced about the solution of iron phosphide in iron.

The point at which salt and water become saturated in any range of temperature is one of equilibrium. Water can be saturated in a wide range of temperature and be in equilibrium throughout that range. If cooled below saturation point, salt will fall out of solution, but it will return into solution if the temperature be raised to the original point.

Iron saturated with phosphide at 1050° C. parts with a portion of it when the temperature falls and sufficient time is allowed to admit of its segregation, and, like the salt solution, it takes it up again when the temperature is raised.

Iron containing less phosphorus in solid solution, saturated at a lower temperature, also parts with its phosphorus when the temperature falls.

So far as the experiments go, free phosphide did not form from solid solutions containing less than 0.6 per cent phosphorus, but it seems more than probable that if the heating at lower temperatures than 700° C. had been prolonged for months or years instead of for hours, crystallization would eventually have occurred. It is obvious that as the metal becomes colder its particles become more rigid, and segregation into crystals must be correspondingly slower.

As the crystals of rhabdite in the Mexican meteorite, embedded in a matrix containing very little phosphide in solid solution, dissolve at 600° C., and possibly at lower temperatures, it is obvious that they must have originally fallen out of solution at relatively low temperatures, probably below 600° C., and then, only after a very extended period of heating.

A crystal of common salt, when placed in a large excess of water, begins to pass into solution at the surfaces, and, if there were no free liquid motion of the solution, the portions immediately surrounding the crystal would become saturated. If the temperature were then lowered, some of the salt would at once pass back from the saturated layers and recrystallize on the solid crystal.

An impossibel condition of rigidity and immobility has been assumed so as to bring it into line with what occurs when a solid dissolves in a solid. It has been shown that on heating iron containing crystals of iron phosphide, the phosphide at first forms strong solutions in iron round about them, and that on lowering the temperature some of the phosphide recrystallizes on to the outside of the remaining portions of the original crystals.

If a crystal of common salt is suspended in water in a nearly saturated solution, and the latter is allowed to evaporate spontaneously until the liquid becomes near the point of saturation, the free crystal will exert attraction and draw to itself the first portion of the salt that tends to fall out of solution before any is deposited elsewhere. This peculiarity is constantly met with in the alloys under consideration.

The large and relatively thick envelopes of phosphide surrounding the columns of Series I. and V.[1] suggest that they were formed in advance before the genesis of idiomorphic crystals in the centre of the columnar crystals of iron, and that their attraction for phosphide of iron was exerted for a considerable distance, a distance corresponding to the width of the borders which surround the layers of $Fe_3P$, borders which eventually became impoverished of phosphide of iron, and then contained less phosphorus than the metal in the centre of the columns which were outside the attractive influence of the massive envelopes. When the temperature fell to the point favorable to the crystallization of the phosphide in the body of the crystals the excess would fall out of solution and appear as idiomorphic crystals of phosphide of iron. As the conditions in the hearth of the blast-furnace were not favorable for the phosphide of iron to fall out of the borders, which are weaker solutions, no crystals appeared in them. The same thing appears to have occurred in the Mexican meteorite referred to in Series II. The rhabdite crystals were fairly evenly distributed, but at intervals there were a few very large crystals, each surrounded by thick borders of metal practically free from any free phosphides.

The actual width of these external borders measured about 0.690 millimetre, but varied with the size of the crystals.

[1]See paper on Blast-furnace Bears.

The solid solutions of phosphide of iron in iron are in some respects similar to solid solutions of carbide of iron in the solvent eutectoid (the hardenite of Arnold), containing 0.9 per cent carbon. The solutions in each become fully saturated at about the same temperature, 1100° C. After saturation, as the temperature falls, crystals of carbide or phosphide, as the case may be, fall out of solid solution, and equilibrium is established within a range at every temperature. They re-dissolve again as the temperature rises. The last trace of carbide, dissolved in the eutectoid, crystallizes out at a point just above the critical point Ar 1-2-3. On cooling below this, the solvent itself breaks up into ferrite and carbide, producing pearlite. In the case of the phosphide solid solutions, the solvent is iron, and there is reason to believe that at some temperature, if almost infinite time were given, all the phosphide would also crystallize out. The exceedingly minute quantity of phosphide remaining in solid solution in the Mexican meteorite may be taken as tentative evidence that such would be the case. There can be little doubt that this interesting alloy took an exceedingly long time to cool down through the range of temperature favorable for the crystallizing of the phosphide.

No reference has been made to the allotropic condition of the respective solvents of carbide and phosphideof iron

We know that the iron in the alloys saturated with $Fe_3C$ above Ac 1-2-3 is in the gamma state. On the other hand, Professor Arnold and others have shown that the alloys of iron and phophide rich in phosphorus do not give any arrest corresponding to Ac3, and the author has found that such solid solutions, in a coarsely crystalline condition, are not refined in structure on heating even at 1200 deg. C., facts which lead one to conclude that the iron in such alloys never passes to the gamma state. When, however, carbon is caused to diffuse into the more dilute solid solutions, the structure is broken up. We may conclude, therefore, that when that occurs the iron changes to the gamma state.

Much more research, however, is required in this direction before one can say we know.

## APPENDIX.

### Methods for the Detection of Phosphorus in Solid Solution.

Solutions of phosphides in steel are attacked by very dilute acid reagents inversely in proportion to the phosphorus present. If a reagent contains a little copper in solution the parts of metal freest from phosphorus are most -readily attacked and stained or colored by a thin deposit of copper. The depth of the coloration in a given period gives a relative idea of the proportion of the phosphide present, but where the iron and phosphide approach saturation, no copper is deposited after a prolonged attack even with a strong reagent.

Three different cupric reagents have been described, one by Dr. W. Rosenhain, another by Mr. J. H. Whiteley, and a third by the author in the first part of this paper, published in 1915.

Although the author's reagent has always given excellent results in his laboratory, many experimenters have not been so successful. Professor H. Le Chatelier pointed out that the reagent might be improved by increasing the quantity of water, and this has been found to be the case.

It has, however, been found desirable to have two solutions, one stronger than the other, for whilst the dilute solution is suitable for etching steels containing a small quantity of phosphorus, it is not so useful when the phosphorus is much increased. The solutions used in this research contained:

| | a. | b. |
|---|---|---|
| Cupric chloride . . . . . . . . . | 1 gramme | 5 grammes |
| Magnesium chloride. . . . . . | 4 " | 4 " |
| Hydrochloric acid . . . . . . . | 1 c.c. | 1 c.c. |
| Water . . . . . . . . . . . . . . . . . | 20 c.c. | 20 c.c. |
| Absolute alcohol . . . . . . . . | 100 c.c. | 100 c.c. |

The attack by the cupric reagent not only stains primarily the parts freer from phosphorus, but bites into the metal, roughening the parts attacked, leaving the phosphoretic parts more or less unaffected and therefore smooth and bright. For this reason the objects when viewed under oblique illumination contain parts which appear dark, and parts quite light, the latter being the lower phosphorus. As it is difficult to illuminate large surfaces by rays veritical to the surfaces, they should be examined under oblique and not direct illumination. As all the work done in this research was upon small specimens which required magnification, direct or vertical illumination was adopted.

In a paper he had read before the Royal Microscopical Society in 1905, reference was made to the fact that aqueous solutions of picric acid, after a short attack, stain solid solutions of phophorus and iron a brown or dark colour. Such a solution is made by dissolving 0.5 gramme picric acid in 100 cubic centimetres of distilled water. It is invaluable in locating the parts in steel which aer more or less saturated with phosphide.

Boiling solutions of alkaline picrates stain free phosphides a dark brown or black, but does not stain solid solutions of phosphide in iron, no matter how concentrated the solution may be. Free carbide of iron is similarly stained; for that reason the reagent does not enable one to distinguish one from the other. One way of doing this, when phosphides and carbides are together, is to heat the polished specimen to about 270 deg. C., when the phosphide will become blue by the time the carbide assumes a reddish brown coloration.

Professor H. Le Chatelier has suggested that electrolytic etching is generally under better control than attacking the specimens with acid reagents.

The photographs in this paper indicate how much can be shown by the application of modern etching methods. Indeed, but for them it would have been impossible to make the research.

## DESCRIPTION OF PHOTOGRAPHS.

### Plate I.

All the photographs represent steel containing 0.3 per cent carbon and 0.3 per cent phosphorus.

Nos. 1, 2, and 3 are of the same area.

Nos. 4, 5, and 6 are likewise of the same area.

All were magnified 50 diameters.

No. 1 was etched with nitric acid in alcohol.

No. 2 After repolishing No. 1, and etching with Stead's strong cupric reagent.

No. 3 After repolishing and etching with an equeous

solution of picric acid.

No. 4 Another section after heating to 960 deg. C. for five minutes and quenching in water, and etching with nitric acid in alcohol.

No. 5 After repolishing No. 4 and etching with Stead's strong cupric reagent.

No. 6 After repolishing No. 5 and etching with aqueous picric acid solution.

**Plate II.**

All the photographs represent a homogeneous alloy of iron and phosphorus containg about 0.5 per cent phosphorus, after carburising by cementation at 960 deg. C. in charcoal.

No. 7 is the cemented bar after polishing and etching with strong cupric reagent. × 2.

No. 8 was quenched in water directly it left the cementation vessel, and was etched with nitric acid in alcohol. The dark areas are martensite, the white parts ferrite. × 100.

No. 9 The same specimen as No. 7, after repolishing and etching with weak cupric solution. × 100.

No. 10 A carburised piece of the cemented bar corresponding to No. 8 after slow cooling from 960 deg. C. and etching with nitric acid in alcohol. × 100.

No. 10a represents the most carburised part of the cemented bar, etched with acid, after quenching from 1250 deg. C.

No. 11 represents a part of the quenched bar farthest away from the charcoal, where carburisation had just commenced, after etching with nitric acid in alcohol and then by a weak cupric reagent. × 330.

**Plate III.**

No. 12 An alloy containing about 2 per cent phosphorus, heated and cooled down with 3 tons of molten blast-furnace slag, after etching with nitric acid. The white parts are free phosphide of iron which had crystallised out of solid solution on slow cooling. × 60.

No. 13 A part of the same alloy as No. 12 after reheating at 1000 deg. C., showing the phosphide passing back into solid solution. × 60. This experiment was made in 1889.

No. 14 A section through three columnar crystals of decarburised iron, found in the hearth of one of Messrs. Bolckow, Vaughan & Co.'s blast-furnaces, showing thick envelopes of free iron phosphide and minute crystals of the same substance in the body of the metal, after etching with strong cupric reagent. × 50.

No. 15 The same as No. 14, after heating to 900 deg. C. for five minutes to cause most of the phosphide to pass into solid solution, and afterwards to 780 deg. C. for six hours to allow it to recrystallise out of solid solution. × 330.

No. 16 A portion of the same specimen after heating at 1000 deg. to 1050 deg. C. for six hours, to cause all the phosphide to pass into solid solution and produce perfect homogeneity, after which it was reheated for six hours at 800 deg. C., to allow the phosphide to crystallise out again. It was etched by boiling in strong picrate of soda which stained the phosphide black. × 330.

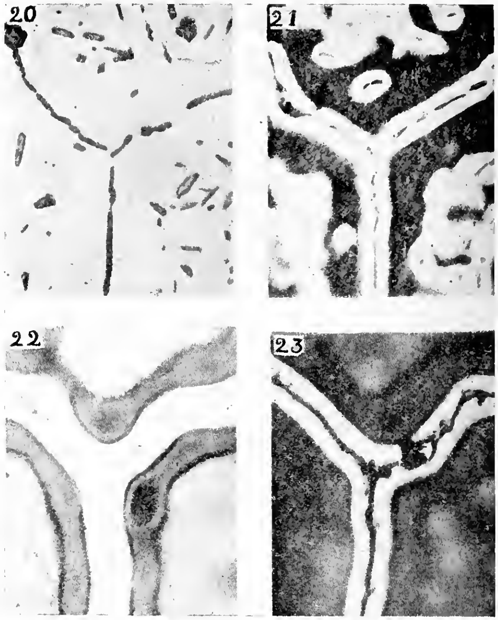



PLATE IV.

No. 17 An alloy containing 2.2 per cent phosphorus, after heating to 1050 deg. C. to produce a saturated solid solution of phosphide in iron, after which treatment — excepting in the binary eutectic areas—there were no free phosphide crystallites. It was then reheated for six hours at 980 to 1000 deg. C. and was examined, after etching with picric acid in water. The minute clusters of white specks are crystallites of free phosphide.

No. 18 A portion of the same metal as No. 17 × 330, after reheating for six hours at 820 deg. C., showing that the minute crystallites in No. 17 have grown considerably.

No. 19 An alloy containing 2 per cent phosphorus, after long heating at 1000 to 1050 deg. C., and afterwards for six hours at 820 deg. C. It was etched by boiling picrate of soda. The large black parts are the remains of the eutectic, the smaller dark parts are crystallites of phosphide which formed on heating at 820 deg. C. × 330.

**Plate IV.**

These photographs illustrate the gradual passage of the phosphide into solid solution by heating for increasing periods at 960 deg. C. the same section of three juxtaposed decarburised columnar iron crystals from a Cleveland furnace bear. No. 23 shows that by reheating No. 22 at 800 deg. C. for one hour a portion of the phosphide recrystallises out again from the parts richest in phosphorus.

No. 20 is the original section. × 330.

No. 21 is the same as No. 20 after heating at 960 deg. C. for five minutes. × 330.

No. 22 The same as No. 21 after further heating to 960 deg. C. for fifteen minutes. × 330.

No. 23 The same as No. 22 after further heating at 800 deg. C. for one hour. × 330.

It is impossible to study the evidence without wondering and trying to connect the known with the unknown. It is, however, important to try, even although what is advanced may require modification.

The research in this absorbing field has just begun, and it is believed that others will endeavour by experiment and observation to shed more light on many points which remain obscure.

As usual, I am under obligations to many friends for assistance in this research: Mr. F. M. Percy of Wigan, Mr. George Ritchie and his chemist Mr. D. Sillars, Mr. F. Outhwaite and his furnace manager and foreman smith, also my assistants, Messrs. Jackson, Scholes, Bellwood and Towers.

By kind permission of some of the gentlemen concerned I have pleasure in stating that rough cut specimens, from the blast-furnace bears and other material used in this research, suitable for microscopic work, will be supplied free of cost, if application is made to me at my address, c/o Pattinson & Stead, 11 Queen's Terrace, Middlesbrough.

## RICH MINERAL FIND.

### Immense Deposit of Potash Sodium Sulphate and Epsom Salts.

A discovery that will prove of untold value to the Allies has been made 30 miles north of Maple Creek in an immense deposit of potash, sodium sulphate and epsom salts, one which experts claim consists of millions upon millions of tons of these minerals. The deposit was discovered in the dried-up bed of an old lake and the work of getting it out will amount to practically nothing.

The whole bed of the lake, which is 2½ miles long and over one mile in width, has been staked and filed on and work will be started at once in clearing away the top layers of dirt and erecting buildings for the carrying on of the development of the bed. The claims have been filed by Saskatchewan men, who will retain their control.

Professor McLaren, of the Saskatchewan University, has examined the minerals and pronounced them perfect, while expert engineers have estimated the deposits at 70,000,000 tons. A branch line of railway is to be run from the works to Maple Creek. It is learned that the MacKenzie and Mann interests were two days late in getting on the ground to file on the deposits.

---

The best melting is done in a cupola where the right quantity of air required to melt the scheduled quantity of iron, is discharged into the cupola at the lowest velocity compatible with its diffusion amongst the fuel at, and just below, the melting zone. Increased velocity may raise temperature and accelerate melting, but this increased velocity is undesirable, since it may have a marked effect upon the iron quite out of place in a cupola, which is a melting furnace pure and simple. Iron will be hardened in a certain ratio with the velocity of the blast, and such a hardening is extremely dangerous to the founder and may ruin his castings.

# High Explosive Shells and Shrapnel

(A Paper read before the Steel Treating Research Society at Detroit.)

By MR. J. M. HALL,

Superintendent, Hamilton Steel Wheel Company, Hamilton, Canada (Member of Society), March, 1918.

In presenting this paper it is not intended to supply technical knowledge but merely to give the outline of the general practice as used by one of the largest and most successful producers of shell steel and shell forgings in Canada.

I think you will all agree that the winning of this war almost entirely depends on high production, viz., the production of trained men, transportation facilities, equipment and the tremendous amount of supplies needed.

When considering an invitation extended by our Mr. Brown to prepare a paper for our meeting here in Detroit it occurred to me that possibly an outline of some of our experiences in the manufacture of shrapnel and high explosive shells might help someone to increase this production.

The information I am giving is taken from the heat treating of 18 pound British shrapnel, making steel blanks for 4.5 inch British Howitzer shells and making the steel and forging the British 6, 8 and 9.2 inch high explosive shells, our present output being over 10,000 tons of finished steel per month. I will not discuss the machining of any of these shells, as in writing this paper I only intend to cover the handling of the steel up to where the required physical requirements are obtained.

The 18 pound British shrapnel is forged from blanks cut from 3½ inch plain rolled steel bars, the analysis being:

| | |
|---|---|
| Carbon | .48 to .60 |
| Manganese | .50 to 1.0 |
| Silicon | under .30 |
| Phosphorus | under .06 |
| Sulphur | under .05 |

The elastic limit of the bars is 19 long tons with an ultimate breaking strength of at least 35 tons and an elongation of 20 per cent in 2 inches. After being pierced and drawn there are no strict physical requirements as the forgings must be heat treated to meet the specifications in the finished shell, which are a yield point of 36 long tons, an ultimate breaking strength of 56 long tons and a minimum elongation of 8 per cent in ⅝ of an inch. The test piece for determining these physical requirements is taken from the shell after it is partly finished and heat treated. In heat treating this steel to these requirements we found that by using the following heat treatment we were able to bring every heat we handle to the requirements of the physical tests:

After the forgings are rough turned on the outside and finished on the inside they are put on end in an oil fired furnace which has a heating chamber about 36 inches square and with the combustion chamber underneath the heating chamber; the furnaces are equipped with pyrometers for temperature regulations. The .48 to .54 carbon heats are slowly heated to from 1600 to 1700 deg. F., then quenched in soluble oil. After quenching the shells are again heated in a similar furnace to from 950 to 1000 deg.

F., withdrawn and cooled in the open air. The .55 to .60 carbon heats are heated to from 1500 to 1600 deg. F., quenched in oil and then reheated to from 1000 to 1350 deg. F., withdrawn and cooled in the air. The higher the carbon the higher the temperature used in the second heat treatment. After giving the forgings this heat treatment the open end is suspended in a metal bath with a temperature of approximately 1100 deg. F., for the purpose of closing in the nose end, which is done in a press built for this purpose. After nosing in, the nose ends are buried in flake mica so as to thoroughly anneal same. The shell is then ready for a test piece to be cut out and the physical properties determined. By following this heat treatment it is seldom necessary to give a second complete heat treatment to a heat of forgings.

One of the most troublesome features in the manufacture of the 18 pound shrapnel is heat treating the shells in large quantities so they would pass the physical tests. With the described method and furnaces equipped with reliable pyrometers properly installed and a good quenching oil the results are highly satisfactory.

In the British high explosive shells the specifications call for the following chemical analysis:

| | Minimum. | Maximum. |
|---|---|---|
| Carbon . . . . . . . . . . . . | .40 | .55 |
| Silicon . . . . . . . . . . . . | .15 | .35 |
| Manganese . . . . . . . . . | .60 | 1.00 |
| Sulphur . . . . . . . . . . . . | .00 | .05 |
| Phosphorus . . . . . . . . . | .00 | .05 |

The physical properties are a minimum of 19 long tons yield, a breaking strength of between 35 and 49 long tons inclusive and an elongation of between 14 and 30 per cent in 2 inches.

Nearly all the steel which we manufacture for high explosive shells is made by the Acid Open Hearth process, the balance being Basic Open Hearth, and the furnaces fired by oil. The capacity of the furnaces is 20 and 40 tons. The information I am giving is taken from the acid steel only due to the fact that we have used the basic furnaces for a short time only. The metal charged is scrap steel and pig iron which is low in phosphorus. The scrap consists of crop ends of plates, shapes, forgings, borings, and turnings from machine shops, etc., the bulk of the furnace charge being scrap, about one-fifth pig iron. After the charge is melted down a snap test is taken for carbon. If the carbon is too high, iron ore is added to the charge until the carbon is brought down to the chemical analysis. If the heat melts low in carbon, pig iron is added to bring the carbon up. When the carbon is in the right proportion and the heat ready to tap silicon and manganese are added in the proper quantities. The heat is then poured into cast iron moulds, one mould is filled at a time and in turn until the whole heat is poured.

In order to produce sound steel without piping or segregation, which is very necessary in producing a first class forging, the moulds must be properly designed so as to allow molten metal to fill in the shrinkage which takes place when the metal solidifies. The first 4.5 inch cast ingots were made about 4 15-16 inches in diameter and from 33 to 36 inches long, which would allow three billets about 9½ inches long to be cut from each ingot. After considerable experimenting it was found not practical to cast a sound ingot in this way as the shrinkage of the steel in solidifying could not be properly taken care of and on account of the small amount of steel required for each blank it is hardly practical to cast the blanks to size, the present method being to roll larger cast ingots into bars of the proper diameter required for making the forgings. For the 6-inch shell the British drawings call for a blank about 6 7-16 inches in diameter and 17 inches long. These cast blanks are cut from ingots cast on end in cast iron moulds with a hot top, one ingot making one blank. The ingot was made heavy enough to give about 20 per cent discard, the discard was on the top end for the purpose of feeding the lower part of the ingot as required in the shrinkage of the steel during solidification. It is now a generally accepted fact that it is impractical to make a sound uniform blank in this way as the solidification of the steel is too nearly uniform from the top to the bottom of the ingot, thereby causing piping and segregation. We overcame this trouble to a great extent by using a 1-inch nozzle in the ladle for pouring the steel which allowed the moulds to be poured slowly and worked quite satisfactory when used on the 20-ton ladles providing the ladle was preheated just before receiving the molten steel.

We have found that by making an ingot 5¾ inches in diameter at the bottom and tapering to 6½ inches in diameter for the first 12 inches then about 7 inches straight and using a 6-inch hot top a sound uniform blank could be cast with a 20 per cent discard on the ingot. The hot top is for the purpose of holding the discard metal in a molten state until the body of the ingot has solidified. We also found that we could cast a tapered ingot with corrugated walls which would give a sound uniform blank with considerably less than a 20 per cent discard, but have not carried this beyond an experimental stage, as it is hardly practical to properly scale this billet in the forging operation which would be liable to cause a scale deposit in the forging. At the present time we are also casting larger billets which are rolled into bars 6 7-16 inches in diameter then cut into three and four blanks about 17¼ inches long. We have found from the physical tests of thousands of 6-inch forgings that the forgings made from the cast steel are equally as good as those made from the rolled steel.

The 8 and 9.2 inch ingots are also cast in individual cast iron moulds with a taper of about ¼ of an inch in 12 inches with the lower end bullet shaped, a hot top being used on the top of the mould. This shape ingot is sound and gives no trouble when made with the usual 20 per cent discard. After the ingots are cold enough to handle they are taken to cut-off machines, partly cut off at the proper length then taken out and broken, allowing an examination of the steel fracture. After passing the chemical analysis and examination by the government examiners they are ready for shipment to the forge shop, each heat being kept separate and intact, also the works analysis is furnished to the forge shop for each heat. The blanks from the rolled ingots are cut off in the same way as the cast ingots. The blanks for the 6-inch high explosive shell, which we are using at the present time, weighs from 158 to 163 pounds, the 8-inch weighs 275 pounds and the 9.2 inch 380 pounds.

At the forge shop the principle operations are heating the steel for forging, forging the steel to the proper shape, cooling the steel after forging, determining the physical analysis, heat treating the forgings if

necessary and inspecting and loading for shipment.

### Heating the Steel for Forging.

In heating the steel billets we are using flat hearth oil fired furnaces, each furnace has a capacity of approximately 100 6-inch billets, 75 8-inch or 50 9.2 inch. The hearth of the furnace is about 7 feet by 14 feet. The burners are located at the ends of the furnaces which have four 24-inch doors at both the front and back where there is also a shelf 18 inches wide extending the full length of the sides. These shelves are used for charging billets and in drawing the heated billets. The time required to charge a furnace, bring the billets up to a forging temperature, hold the forging temperature for about 15 minutes and draw the charge is about two and one-half hours. The forging temperature is from 1800 to 2000 deg. F. We have found that it is very essential to bring the billets up to the forging temperature, hold this temperature until the billets are heated uniformly and in drawing the billets to have them falling in temperature rather than rising in temperature and that if the billet is unevenly heated or at a higher temperature on the outside than at the centre the results will almost invariably be an eccentric forging. If the forging temperature is below 1800 deg. F. it is almost impossible to properly remove the scale from the billet before forging, which for a high production must be done easily and quickly. There are a number of forgers using continuous furnaces with very good success but as two or more furnaces are required to heat enough steel to keep one piecing press in operation continuously, together with the trouble in feeding the cast tapered billets through a continuous furnace we have found we could not increase our production by using the continuous furnaces.

### Forging the Steel.

Next after heating the steel I believe the most important part in high production is the forging equipment. There are a number of methods used in making shell forgings. Some of these are to press the heated billet into the die with a tool which approximately fills the opening in the die. This operation is commonly called bunting, this bunting operation also makes a depression for starting the piercing pin. After bunting, the billet is then pierced with a piercing pin making a blank which resembles the shape of the finished forging but shorter and larger in diameter. This blank is then forced through a ring or series of rings which reduces the diameter and at the same time increases the length of the forging. This last mentioned operation is commonly called drawing, and is generally done without reheating the forging, although some manufacturers reheat for this drawing operation. Some manufacturers first after placing the billet in the die bunt the steel and then pierce thereby obtaining a forging to size without drawing, while most of the manufacturers in Canada at the present time are making the forgings to size by a piercing operation only, which requires a round blank.

We have carried out tests to determine whether or not the steel was better physically by using either of the three methods and could find no difference whatever and that forgings made by one operation only are equal or better than a forging made by either of the other methods. Our apparatus for forging consists of electrically driven hydraulic pumps capable of maintaining 1500 pounds pressure and the well known vertical hydraulic press, with a hydraulic accumulator of sufficient capacity to operate all presses in making one forging each should the pumps be stopped. We have found that it requires approximately 15 tons per circular inch projected area of the piercing pin to pierce shell steel heated to from 1800 to 2000 deg. F., varying somewhat on the shape of the piercing pin and the taper of the die.

The 4.5 and 6 inch forgings are forged with a solid base, the open or nose end is heated and nosed in by a small press after being rough turned and finish bored. The 8 and 9.2 inch are forged with a solid nose and after machining an adapter is screwed into the open or base end.

The press equipment consists of a die base, die, die cover, combination piercing pin guide ring and stripper, piercing pins and piercing pin holders. The die base is bolted and dowelled to the bottom or stationary press platen and the piercing pin holder bolted and dowelled to the top or moveable press platen. The die base contains a small hydraulic cylinder fitted with a loose piston which serves to eject the forging from the die after being pierced and supports the die in which the shell is forged. The die is a steel casting bored out to receive a cast iron liner which is pressed into place. The die cover tends to hold the die liner in place and contains a seat for the guide ring and stripper and also has jaws for holding the guide ring and stripper in stripping the forging from the piercing pin. The stripper and piercing pin guide ring brings the piercing pin to the centre of the die in piercing and strips the forging from the piercing pin. The piercing pin holder is a revolving chuck holding two piercing pins either of which may be swung into position for piercing. One piercing pin will immerse in water at the time the other is piercing, this tends to keep the pins cool and at the same time allows a short stroke to be used on the press for the pins may be swung from over the die to allow the forging to be removed and a billet to be placed in the die.

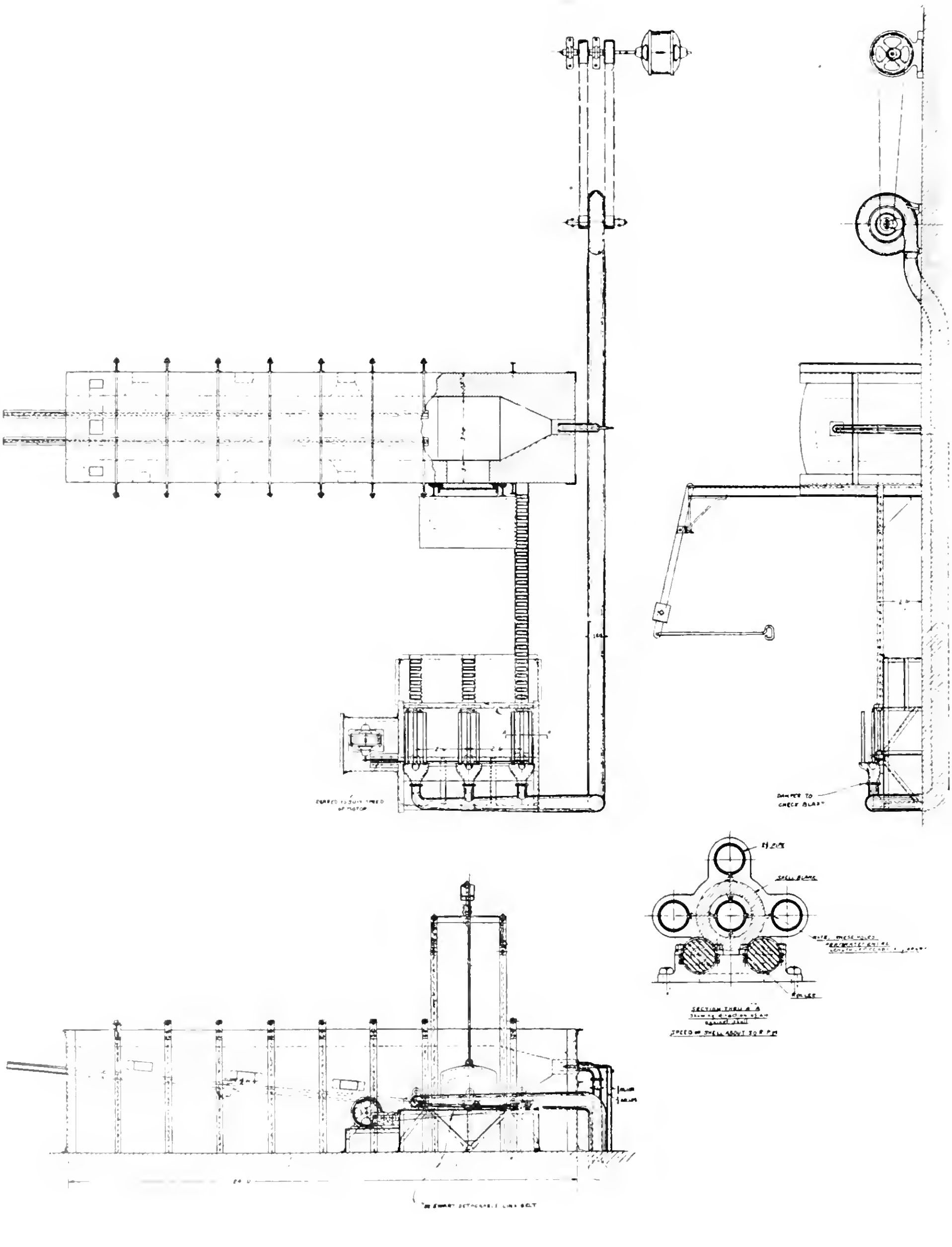
The life of a die liner with a wall thickness of about one-sixth the bore and with circulating water in annular grooves around the outside of liner is about 1500 forgings, which is more than twice the number obtained from a liner cooled by applying water on the outside of the die pot.

The length of piercing punches required for making shell forgings is from six to seven times the diameter. It must stand a working load of approximately 40,000 pounds per square inch in compression besides the tremendous pressure of hot metal passing over the nose in piercing. For good service this requires a high grade steel and after experimenting with various grades we have found Chrome Vanadium steel with the following analysis and heat treatment gives very good service:

| | |
|---|---|
| Carbon . . . . . . . . . . . . . . . | .50 to .60 |
| Manganese. . . . . . . . . . . . | .50 to .80 |
| Chrome . . . . . . . . . . . . . . | .70 to 1.1 |
| Vanadium . . . . . . . . . . . . | .15 to .25 |

This Chrome Vanadium steel is cast in ingots, forged, rough turned, heat treated and then finished turned to size. The heat treatment is as follows:

Heat slowly to 1550 deg. F., quench in oil, reheat to 800 deg. F. and then cool in air. The life of one of these piercing pins with one redressing at the nose


DAMPER TO
CHECK BLAST
SHELL BLANK
SECTION THRU A-A
SPEED OF SHELL ABOUT 30 R P M

end is about 3500 forgings. With this described piercing equipment we have been able to get an average output of approximately 100 6-inch, 80 8-inch and 50 to 60 9.2-inch forgings per press per hour.

### Cooling the Steel After Forging.

After forging, the next very important step is to properly cool the forgings which, when handled in large quantities, is no small task. The specifications require that all forgings must be cooled without coming in contact with each other. This will not allow the forgings to be stacked in piles while hot and thus retard the cooling which, with the outside protected from drafts, I believe would be an ideal way to cool the high carbon heats, as this would tend to increase the elongation in the physical test. The low carbon heats should be cooled as quickly as possible in order that the yield in physical test does not fall below 19 tons.

In 1917 our forgings were taken from the press conveyors at about 1600 deg. F., placed on end at from 6 inches to 3 feet apart, which distance varied with the carbon contents, the higher the carbon the smaller distance apart, allowed to cool to about 700 deg. F. and then piled. From this method of cooling 86.3 per cent passed physical test without heat treatment, 9.3 per cent required annealing, 1 per cent normalizing, 2.6 per cent air cooling, and .8 per cent were not brought to the physical requirements, all of which were outside the chemical specifications, most of them being low carbon heats and scrapped before we installed the Sandburg air treatment system.

At the present time we are using a slow moving conveyor which carries the hot forging received from the press, the temperature of the forging being about 1700 deg. F., through a sheet iron tunnel with ventilating doors and stacks for carrying off the heat. The forgings are cooled to 800 deg. F. in from one to two hours, according to the carbon contents, the rate of cooling being regulated by dampers in the cooling stacks and doors in the casing. The apparatus looks very promising as it cools the forgings uniformly, and we believe is giving us less physical failures, but as it has not been in use for a long enough period I can give no exact figures on this. After cooling to about 800 deg. F. the forgings are piled in compact piles.

### Taking Physical Test.

After cooling the forgings and piling same the next step is cutting the test bars. The average amount of test shells selected for physical analysis is about 2 per cent of the total forgings. Two test bars are cut from each selected forging from near the base end. Where the plant output is large this is a large item and after trying different methods in cutting these test bars such as milling machines, hack saws, a combination of both and the acetylene torch we have found the cutting torch the best.

The test bars are cut 1½ x 6¼ inches and 1½ x 7¼ inches, the large bars are for both tension and compression tests and the small ones for tension only. According to revised specifications, in addition to tension tests on every heat, we are required to make a fracture test from every second heat and a compression test from every tenth heat. In order to minimize the possibilities of errors and mixups in the selection of these various tests we adhere to a very simple rule: All heats with numbers ending in 0 are cut for compression and tension, all even numbered heats are selected for fracture test, for example, Heat No. 4118 would have the usual tension test and in addition a fracture test would be made; No. 4119 would have tension test only, while No. 4120 would have tension, fracture and compression tests. The fracture test consists of cutting the test forging off about 2½ inches from the base end and then splitting same so as to permit the examination of the base end.

All of this cutting is done on a specially designed machine for the purpose. The machine is built up of a frame which carries two horizontal rollers for carrying the forging to be cut, these rollers may be operated by a crank which revolves the forging. The cutting torch is carried on a rest which can be moved transversely, longitudinally and vertically by separate screws operated by cranks. In cutting off the base end of the forging the cutting torch is brought to the proper place when the forging is revolved at the proper speed, cutting the base entirely free from the balance of the forging. This base is then cut from two sides towards the centre so as to allow splitting with a wedge which makes the base end fracture. The test bars are cut to size by the longitudinal and transverse movement of the torch, the vertical movement being used for torch adjustment only. This apparatus makes a straight clean cut about 1-16 of an inch wide and brings up the temperature of the test bar very little and gives equally as good a test bar as if cut out by any other method. After these test bars are cut from the forging they are turned in a lathe to ¼ square inch area and sent to the Government Testing Laboratory to be pulled and they report the physical results to the manufacturer. When the physical results are received the heats which are O K are inspected for size and concentricity and shipped. The heats which fail physically are heat treated accordingly and then again submitted for test. We have found that it requires on an average of about four days to take a heat through the forge shop, that is from the time the blanks are received until the forgings are shipped. This average includes both the heats which require a heat treatment and those which do not.

### Heat Treating the Forgings.

There are three distinct heat treatments we are giving our high explosive shell forgings, namely, Annealing, Normalizing and Air Cooling. The heats annealed are high carbon heats as high as .60 carbon, which have failed on account of too high an ultimate, too low an elongation or both. The normalized heats are those which failed physically and do not pull according to their chemical analysis which may be caused by improper cooling or overheating, and also low carbon heats which fail but almost pass in yield, or heats which fail in both ultimate and yield. Heats to be air cooled are those which fail in yield the ultimate also being low.

The average analysis of 50 heats which passed physical tests without heat treatment is:

| | |
|---|---|
| Carbon | .49 |
| Manganese | .67 |
| Silicon | .25 |
| Sulphur | .036 |
| Phosphorus | .044 |

The average analysis of the heats annealed is as follows:

| | |
|---|---|
| Carbon | .53 |
| Manganese | .77 |
| Sulphur | .039 |
| Silicon | .21 |
| Phosphorus | .043 |

their physical failure being in elongation and too high an ultimate. The annealed heats as a rule were heated to 1600 deg. F., held a short time and then cooled in a closed furnace. This reduced the average ultimate 3.2 long tons and increased the average elongation 6 per cent.

The carbon range of the heats which require air cooling are heats below .44 carbon. The average analysis of the air cooled heats is:

| | |
|---|---|
| Carbon | .42 |
| Manganese | .66 |
| Silicon | .25 |
| Phosphorus | .043 |
| Sulphur | .046 |

The Sandburg air cooling treatment which we are using consists of heating the forgings in a continuous furnace to 1550 deg. F., then placing them on a pair of live rollers which will revolve the forging about 30 or 40 revolutions per minute. While the forging is being revolved one perforated pipe sprays the inside of the forging with air delivered from a fan at about 12 oz. pressure and three pipes spray the forging on the outside. The volume of air is delivered at the rate of approximately 400 cubic feet per minute per 100 pounds weight in the forging. This will cool the forging from 1550 deg. F. to 800 deg. F., in approximately seven minutes. This air treatment has given us wonderful results. Our failures from this treatment are less than 1 per cent producing a raise in the average ultimate of 3.6 long tons, reducing the elongation only an average of .6 per cent and bringing the yield point up above 19 long tons.

The normalized heats were heated to 1500 deg. F., taken from the furnace, stood on end and allowed to cool in the air. The forgings were placed about three feet apart. These heats as a rule were low in carbon or heats which did not show physical properties according to their chemical analysis. We have entirely discontinued this practice with the low carbon heats and use the air cooling treatment instead.

In going into the shell manufacturing business it is necessary to get a very high production in order to be successful. We have worked with the idea of performing as few operations as possible and making each operation as simple as possible. When taking into consideration the increasing cost of raw materials, the trouble experienced in obtaining proper equipment and supplies, the increasing cost of labor and trouble in getting skilled help, it is very necessary that a high production be obtained and maintained. I believe the production of our forge plant is higher per unit by far than any forge plant in the United States or Canada, and should any of you gentlemen at any time desire any details or further information or wish to visit our plant, we are only too ready to do anything that will help toward giving Kaiser Bill his trimming.

# Theory and Practice in Gating and Heading Steel Castings

By RALPH H. WEST, Cleveland.

A paper read before the American Foundrymen's Association at Cleveland, Sept., 1917.

In accepting the subject of this paper for presentation before this society, I must first state that my remarks are based on my own practice and experience. They are offered in order to stimulate discussion so that in the end the trade may receive some valuable data, to be used in a later compilation. I am aware that the subject is a very broad one, presenting many angles, but for the present we must be content with such data as can be produced relative to general castings and steel foundry practice. As the business with which I am now connected deals mostly in light and medium weight castings, I shall of necessity confine my discussion to this field, including general work weighing from one pound up to 500 pounds.

### Theory is Developed From Experience.

We are to discuss theory and practice. All arts have been founded on practice, and time gives experience. It is only through this experience that we are able to form any theory.

The steel founder receives an order from a customer for steel castings. This order may be for one or 100 castings, involving a like number of methods of procedure. As a quantity order may necessitate machine molding with intricate rigging, I shall confine my present remarks to the small order problem. The first question which confronts the foundryman is how he can most economically and practically produce the steel casting required, to the satisfaction of both his customer and the company. This problem involves two main factors—the mold and the liquid metal, the case at hand being molten steel.

In order that the molten steel may enter the mold, we must provide a pouring hole or gate, so that the mold will receive the metal as rapidly as required, according to the size and section of the piece being made. The gate also should be arranged so as not to interfere in any way with the production of a perfect casting.

The temperature of the molten steel varies; therefore practice determines the conditions governing size of gate. But the location of the gate in the mold must be determined by knowledge and practical experience. After the steel foundryman has determined the best location for his gate, he must then consider the problem of shrinkage. Molten steel in passing from the liquid to the solid form will shrink from 3-16 inch to $1/4$ inch per foot of length. The foundryman, therefore, must provide practically all steel castings with some form of a reservoir to feed or take-up the shrinkage as it develops, so as to form a solid casting. This feeder or reservoir is commonly called a head.

Green sand has a natural bond, and presents a greater chilling action to the liquid steel than dry sand, thus requiring in most cases a lesser percentage of metal in the head to feed the casting or to offset the shrinkage. I am assuming that my readers understand that a dry-sand mold is simply a green sand mold with a special facing, placed in an oven and dried or baked so as to eliminate the moisture, thus presenting a bet-

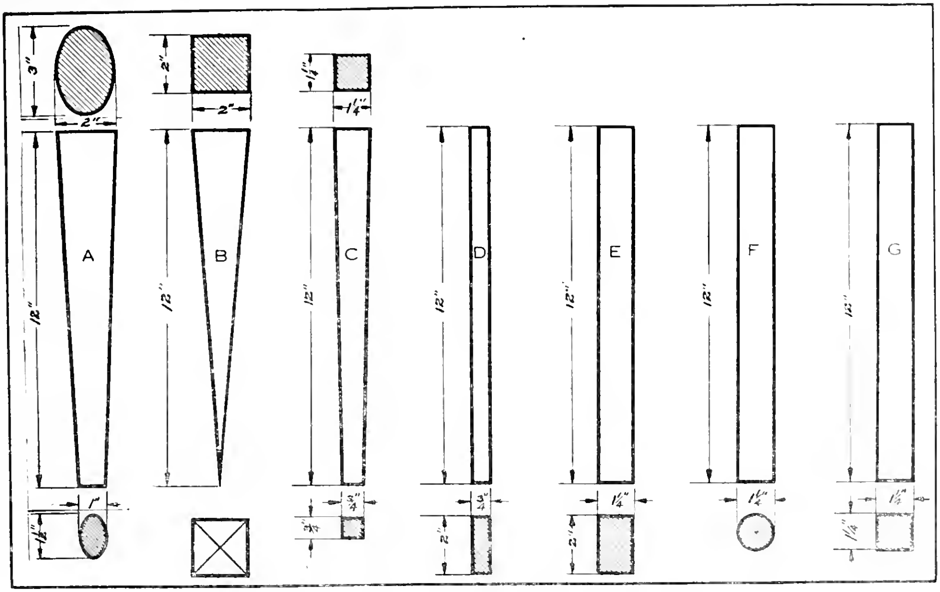


Fig. 1.—Diagram of open mold test bars, showing sizes.

ter surface to the molten steel for final results.

As the shrinkage problem varies according to the shape and form of the casting as well as according to its sections, we shall present some standard forms of test bars to illustrate various shrinkage prenomena. For the purposes of comparison, and in order to properly classify and possibly theorize with respect to different sections of castings, the shapes and sections of test bars shown in Fig. 1 were selected. The test bars were molded in both green and dry sand. They were poured from the top, without any gate and with no extra head. This is commonly known as an open mold, poured through the head and cast on end. Test bars A, B, C, etc., Fig. 2, were cast in dry sand. Test bar A', B', C', etc., were cast in green sand. There is a very strong contrast in the shrinkage cavity due to the different chilling or cooling effects of the molds. Note especially test bars C and C'. This is a common section and one that can in most cases be cast without a feeding head. The green sand mold shows practically a solid bar. Taking the various sizes of test bars, it becomes very evident that any section 1-inch or over requires some form or means of feeding to avoid porosity. It is also true that all shrinkage remains in the top of properly molded and poured castings.

The next set of tests, shown in Figs. 3, 4 and 5, covers standard test bars with different forms of heads or feeders, such as may be found in all steel foundries. Fig. 4 shows bars cast in dry sand and Fig. 5 those cast in green sand. Fig. 6 gives the dimensions of the heads and of the test bar which is shown at M. This bar contains 32 cubic inches. Head A'', Fig. 6, contains 28 cubic inches; B'' and D'', 10 cubic inches; C'', 12½ cubic inches, E'', 20¼ cubic inches, and head F'', 9 cubic inches.

As in the previous test, the green sand bars are easily distinguished from the dry sand bars, showing greater solidity.

Only two bars can be considered to answer practical safe conditions. Bars A and E. No doubt bar A has an excessive head and can be reduced so that we might call bar E the proper standard for a head. In this bar the ratio of head to casting is as 20 cubic inches is to 32 cubic inches. There is 38 per cent steel in the head and 62 per cent in the casting. If we can accept the above test as an average standard, we are then able to compare our daily cast report against our daily shipments of castings, obtaining either good or bad returns according to the class of work produced. We must also consider the question of loss of steel in gates, which becomes excessive to the producer of small castings.

### When the Molder is Turned Loose.

Giving the ordinary steel molder a pattern with simple instructions to head and gate the casting, often leads to defective work. He may have a gate at hand which will answer for the main point of importance is where the gate or its extremity, the sprue, attaches to the casting. This point can be properly sized and cut with the molder's tools, while the upper part must be large enough to admit the steel properly. It is often too large, resulting in considerable loss of metal. The head in many cases is peculiar to the pattern at hand and to obtain the best results ought to be cut and shaped before handing pattern to the molder.

In some foundries standard gates are prepared for every job that may come up. The heading, however, is left open to the molder. This method of procedure is not always practical, but when it can be followed the decrease in the percentage of bad or defective work will soon pay the expense of such a department. It is to the foundry what a tool-room or jig department is to the machine shop. There is no question but that an efficient molder can rapidly improve his knowledge of heading and gating by making it his special work, thus relieving the foreman of this important

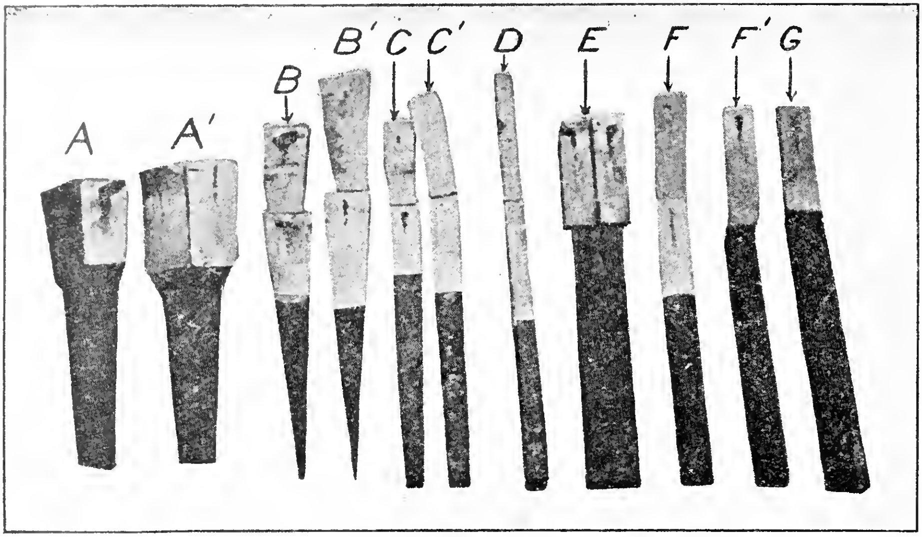



Fig. II.—Test bars without heads showing shrinkage.

duty. This gives a tone to the foundry system that goes a long way toward accuracy and the repetition of good results.

It is common in the steel foundry today when two out of 10 castings go bad, to say, "Well, John made all of those castings the same way," when if exact reproduction could be obtained, one would find the heads and gates to be located in as many different points as the casting surface would allow. There are few of us who never forget and this little weakness causes many defects in our steel castings which can be lessened considerably by some such method as I have outlined.

Our problem would be very simple indeed if all castings presented regular standard forms, but, as is well known, the engineer of today must build efficient machines, and this involves little consideration for the foundryman. It is his problem alone to produce solid, perfect castings from a network of confused shapes and sections run together, light to heavy and curved to straight, at any angle.

Many steel foundries have developed specialties, also methods of producing steel castings peculiar to their own requirements. In order that we might consider some well known standard forms, I have selected a number of patterns which will now be discussed. Also in order to be able to present to the society some other practice than that peculiar to my experience, I have requested a number of steel foundries to outline their methods of producing the same castings.

**Gating a Simple Casting.**

The first of these castings is shown in Fig. 7. It is a cylindrical casting which is to be finished all over. The top under the head forms a cut pinion, the bot-

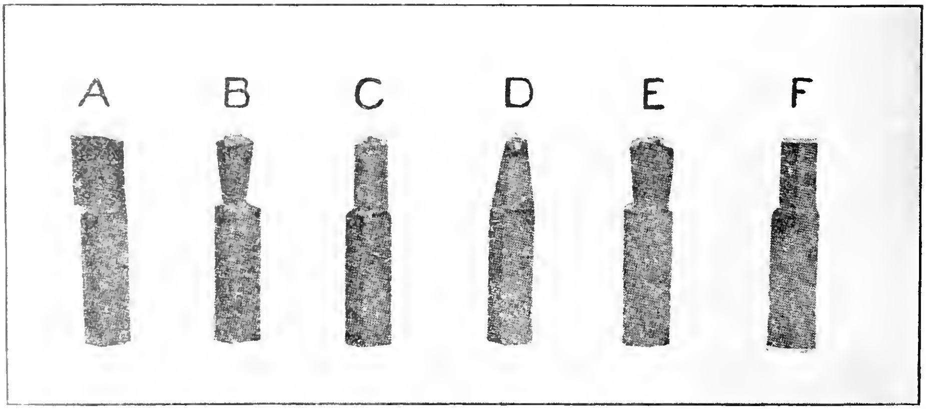



Fig. III.—Test bars with six different forms of head.

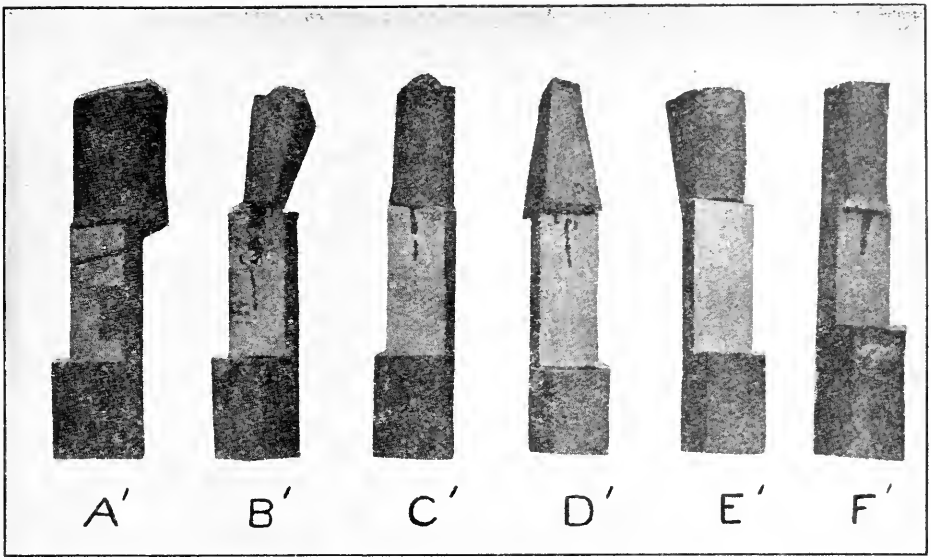



Fig. IV.—Test bars with various forms of head cast in dry sand.

tom plate of the casting being a friction surface for a brake. The form of the casting is simple, but as a perfect, solid job must be obtained, it is preferable to cast it on end with a large head on top. The gate or sprue must be run to the bottom of the mold so as to give clean steel in the finished job.

Two practical points must be observed in forming the mold. First, in cutting the sprue, keep the area of the cross section at XX smaller than the cross section of the casting, otherwise when the gate freezes, it will pull a piece out of the casting at the joint. Secondly, the molder must be careful to remove the sand around the head before the casting sets, so as to avoid a check or crack in the main body. One way to avoid such losses, is to place a chill ring around the pattern at the point shown. This method will answer in some cases but not in all. The casting illustrated being heavy at the bottom, will require feeding, therefore, placing a chill at the middle would not allow the head to feed the bottom. This would leave shrinkage in the lower end. If the middle section of such casting is too light to feed the bottom, the foundryman must use his judgment in regard to using two large heads, one on each end. The replies to my letters of inquiry outlined two methods of casting on end as described. A third method, to cast flat with two heads, one on each end, also was suggested.

### Gating a Circular Casting.

Fig. 8 shows a standard form of circular shell casting, in the case at hand a magnet frame. Our experience has taught us to cast as illustrated, with three or four heads on the rim according to the section of the casting, and to gate between the feet with a bottom gate. The main points to be considered about such castings are first, to properly feed the heavy sections called pole pieces, and second, to gate so as to distribute the metal as evenly as possible around the circle. The poles, if concealed below the top section, will have to be chilled either by nailing or placing iron chill in the rear of the mold, held in place in the sand form.

The gate should be located as near the bottom as possible and so directed as not to cut or wash the inner surface of the core when entering the mold. Also, caution is necessary at the point of connection marked XX as outlined in the discussion of Fig. 7. Particular attention is necessary in all circular forms to relieve the casting of strains, by digging out the centre core as soon as the metal is set. Some foundrymen pour water into the centre of large cores to soften them at once. This is known as a water gate.

Replies received from three foundries regarding this job agree as to methods of heading and gating.

Fig. 9 illustrates a light shell casting having extensions in the form of legs terminating in bosses. They must be fed so as to avoid shrinkage spots. It is possible, when casting such light sections, to omit the necessary heads, providing simply a gate or entrance for steel at one end and an outlet or relief at the other end. The main point in such a casting is to core it so as to give a clean casting and to avoid stresses when the metal shrinks. Three communications from foundries agreed with these suggestions.

Fig. 10 shows a gear blank, a casting common to all foundries. It must be clean and solid with no dirt or shrinkage. At the plant of the West Steel Casting Co. we have established a system of casting all gears on end, even as large as 4 feet in diameter. The sketch clearly illustrates the method of molding, which gives a clean, solid job. In the heading and gating of such a casting, cast on end, the shrinkage is troublesome and it is necessary to distribute the metal evenly so as to avoid all hot spots, causing checks.

In comparison with this method consider a gear cast flat with the four or five heads necessary to feed it. Fig. 11 shows such a casting from actual practice.

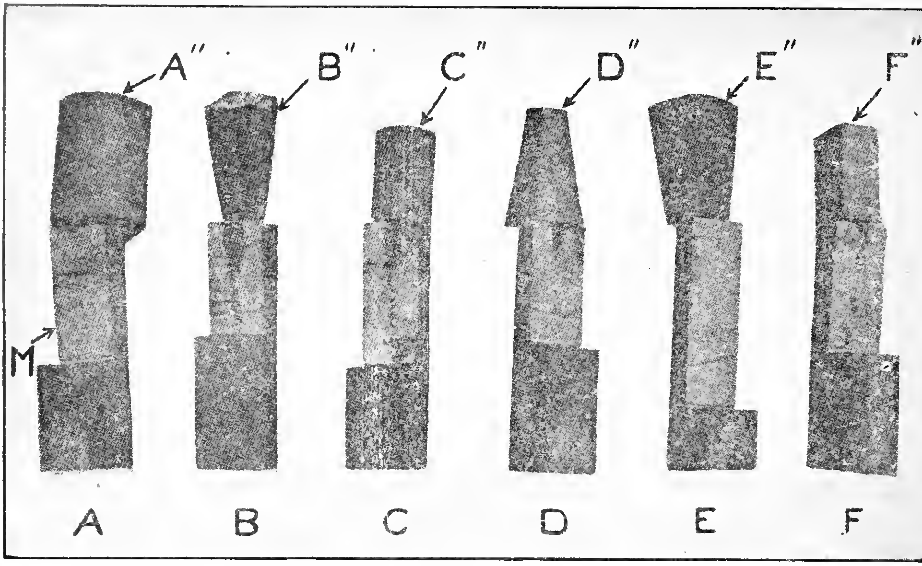



Fig. V.—Test bars similar to those shown in Fig. IV., cast in green sand.

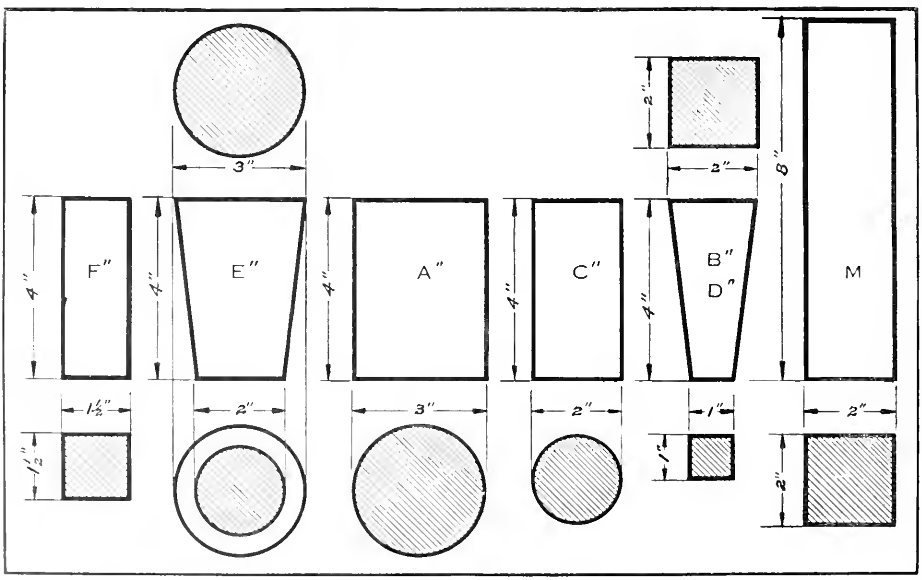



Fig VI.—Diagram of shrink heads, showing sizes. Dimentions of test bars are shown at M.

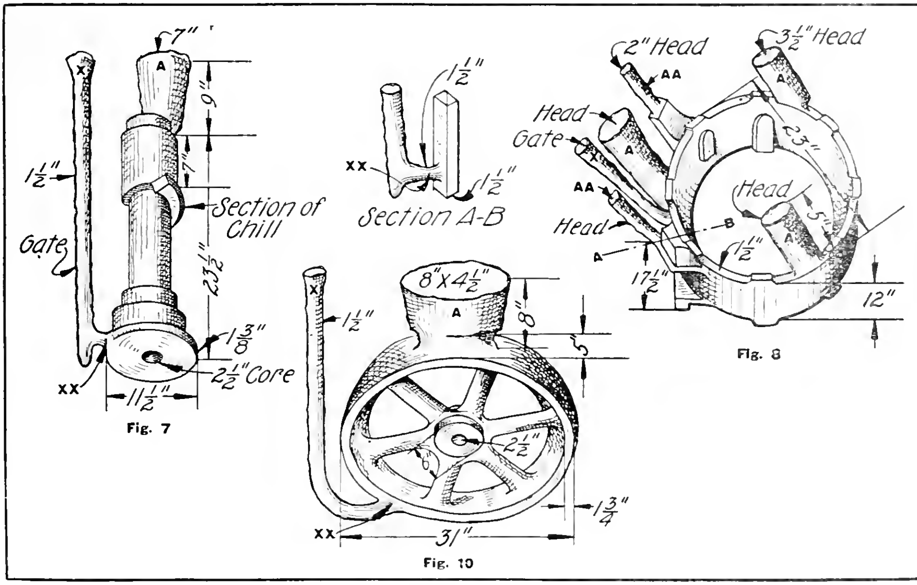
What steel foundry can make a profit out of such waste of metal in heads or risers? It is a safe bet the heads weigh twice as much as the casting. Communications received by the writer from three foundries, however, gave two in favor of casting flat to one on end. Also consider the two different methods of gating shown in Figs. 12 and 13. The weight of the head on the casting shown in Fig. 12 is 66 pounds; those on the casting shown in Fig. 13 weigh 120 pounds. The latter has a bottom gate under the hub.

Fig. 14 shows a common form of lever or bracket casting, having a curved section with holding lugs. Such castings usually require caution in gating only so as to avoid checking when the metal shrinks. The heavier section or connection must be chilled and the ends relieved with pop heads, or whistles, simply to allow the gases to escape quickly. My replies to inquiries were all in agreement.

ing and cleaning head. The method illustrated in Fig. 18 will always show shrinkage and dirt in some parts of the cut gears. Also, the decrease of metal on heads is a deciding point to the foundry in favor of the method shown in Fig. 17. In answer to my inquiries, three replies were received and they all advised the method of Fig. 18.

### A Troublesome Cross-Head.

Fig. 19 represents a common form of casting having a bearing section connecting a ribbed or boxed section. The casting shown is a cross-head and a troublesome one to get solid at the base of the shoulder marked BB. If the section of BB is not large enough to feed the lower body, the foundryman must not hesitate to notify the engineer of the necessary stock required to make a solid casting, and to mold accordingly. Some foundrymen place chills around the shoulder BB, but this practice does not allow the head to feed metal




Figs. VII., VIII. and X.—Sketches showing different methods of gating.

### Gating a Bull Pinion.

Figs. 15 and 16 show two methods of casting common bull pinions. The method shown in Fig. 15 is preferable as it gives a clean casting when machined. It is easy to mold with a minimum of labor and weight of metal in the heads necessary to feed the casting solid. The method shown in Fig. 16 not only requires more labor to form the casting, but requires greater skill to produce a clean casting when finished. My replies, however, gave two shops in favor of the method of Fig. 16 to one of Fig. 15.

Figs. 17 and 18 show two methods of heading and gating what is known as a double gear. This form of casting is very troublesome, as success in one part is at a sacrifice in the other. Our experience has taught us that we obtain the best results by the method shown in Fig. 17. This is the same as if we had two independent gears, each being provided with feed-

under the chill and therefore results possibly in a weak finished casting.

Figs. 20 and 21 present two methods of casting heavy bodies in molds so as to eliminate shrinkage as much as possible. This refers to dry sand molds where the casting are finished all over. Fig. 20 shows a casting setting on a chill. It is gated at the top, the metal falling on the chill. This method allows the hot metal to flow directly into the head, requiring only a small amount of steel, possibly 20 per cent, to feed a solid casting. Fig. 21 shows a common method of molding such a casting, with a bottom gate and a large head on top. Steel foundrymen all know that to get a solid casting by such plain methods requires at least as much weight in the heads as in castings.

Fig. 22 illustrates a standard collar or sleeve used by many automobile builders. It is a troublesome little casting. The shoulder marked "chill" has no

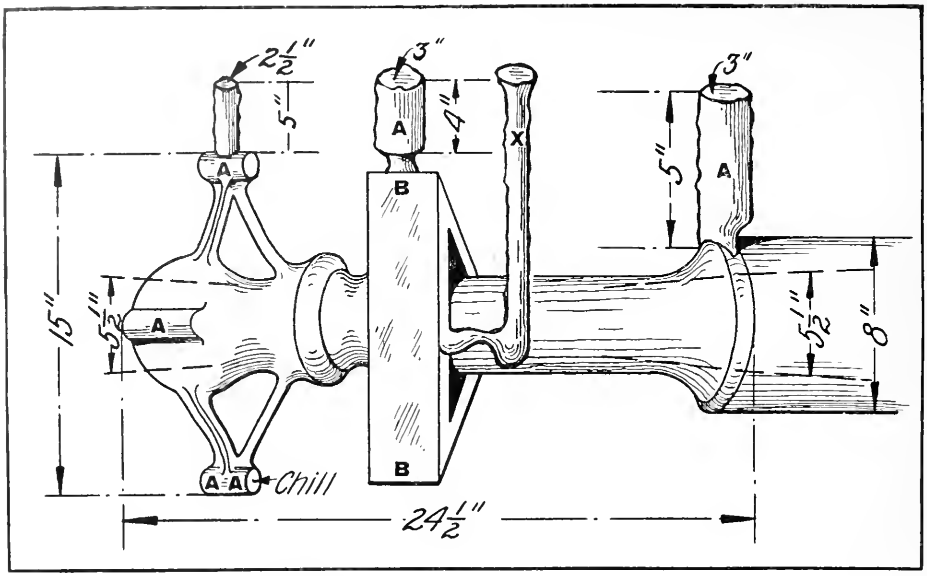


Fig. XI.—Wheel with shrink heads that are too heavy.

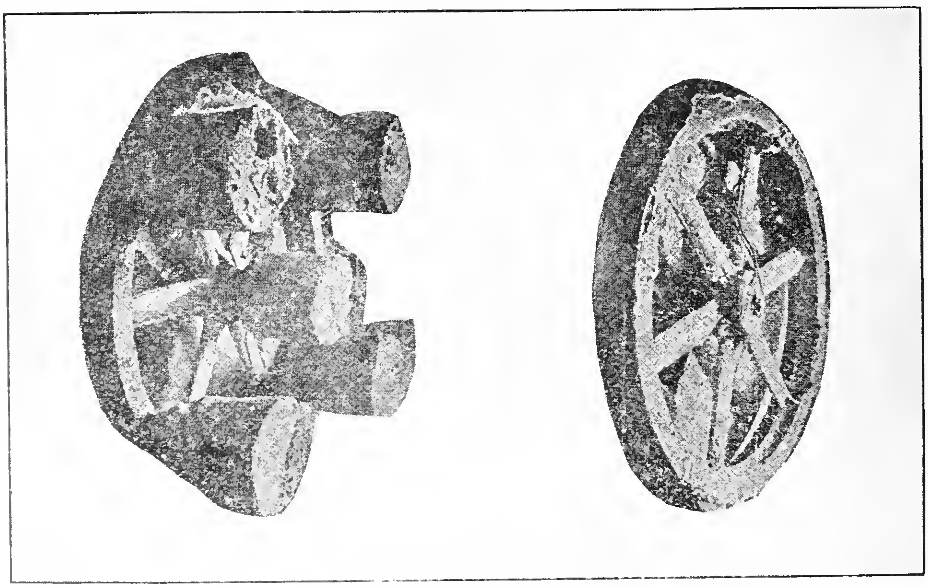


Fig. IX. - A difficult steel casting to gate.

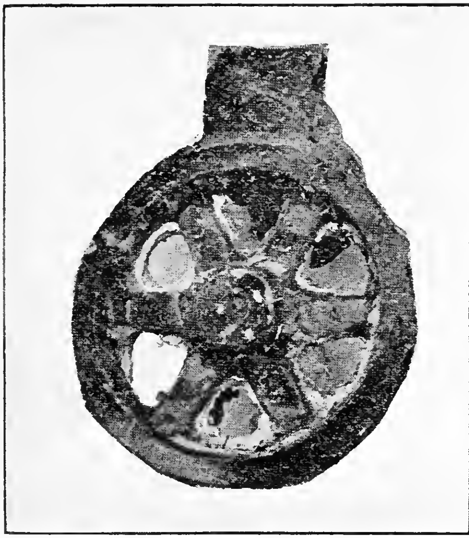


Fig. XII.—A satisfactory method of heading a wheel.

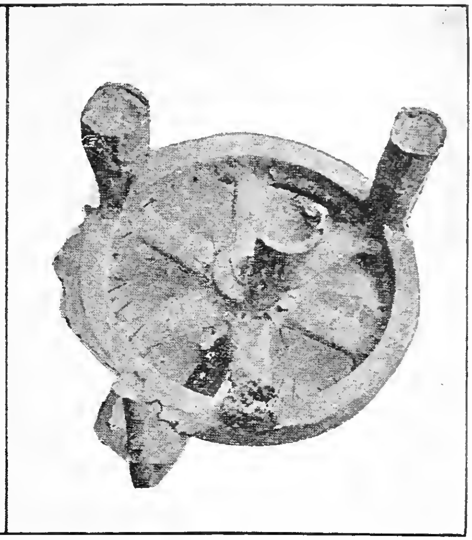
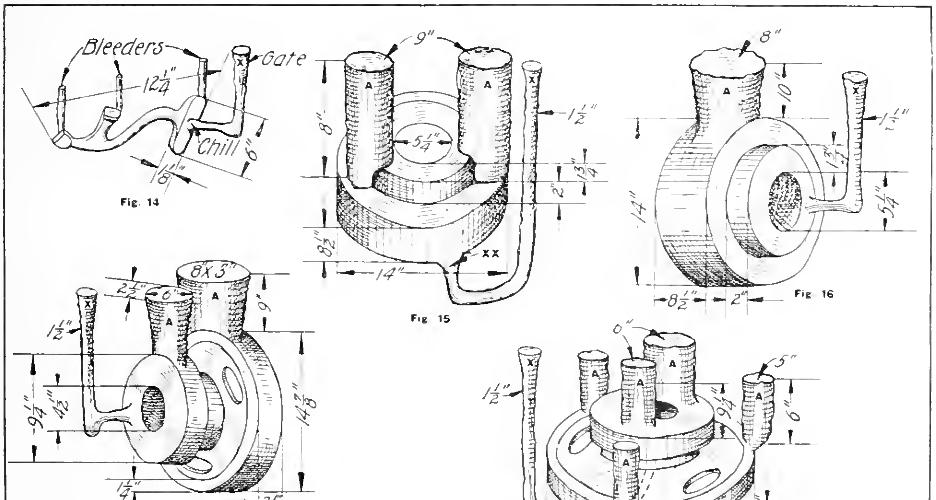
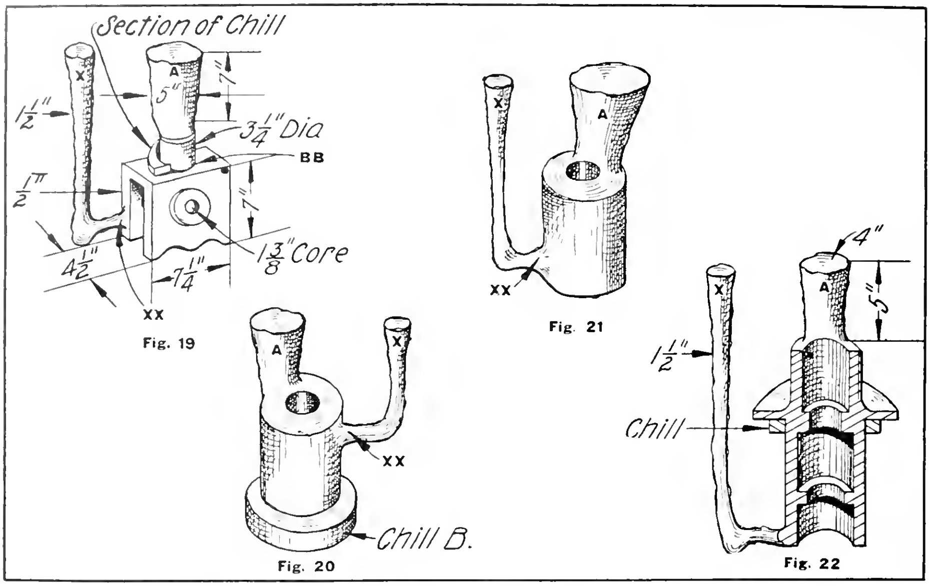


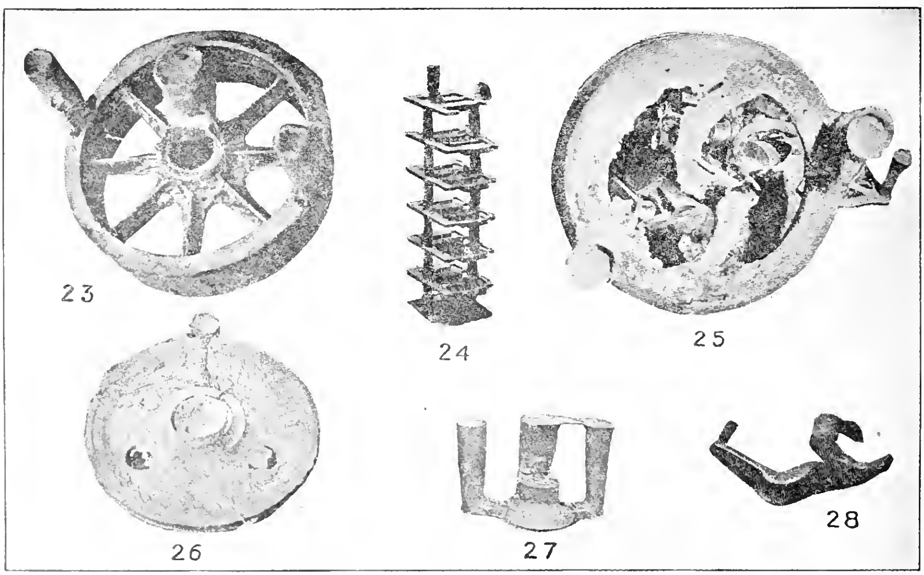
FIG. XIII.—A wasteful method of heading a wheel.



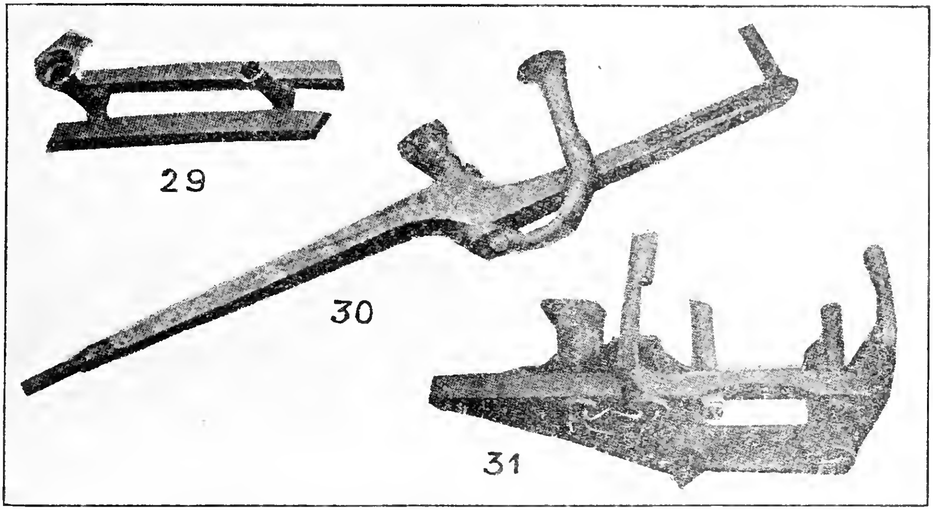

Figs. XIV., XV., XVI., XVII. and XVIII.—Sketches showing different methods of gating.




Figs. XIX., XX., XXI., and XXII.—Sketches showing different methods of gating.




Figs. XXIII., XXIV., XXV., XXVI., XXVII., and XXVIII.—Steel castings properly gated and headed.



Figs. XXIX., XXX., and XXXI. —Properly gated and headed.

direct way of feeding the metal above and at each end, being too light in section to feed the inside section. It, therefore, becomes necessary for the steel foundryman to use his best knowledge, and set all the metal evenly by placing chills at the under section, as shown. Solid, perfect steel castings are often produced by pouring the metal slowly, being sure that enough steel passes through the mold and into the head, the casting setting and forming as the pouring finishes.

Fig. 23 illustrates one method of producing steel wheels. These may be gated either into the arms, ribs or hub.

### Stack Molding.

Fig. 24 shows a method used in some foundries for molding and pouring small castings. It is called multiple or stack molding. The gate enters mold on the side, allowing the gases or riser to flow off opposite side. This system is troublesome, especially when only one gate is used, as the confined gases will not allow the steel to fill the bottom molds.

Fig. 25 shows a drum or method of casting a plain flange or circular ring. Two light heads on the rim and S-gate in the centre are all that is required.

Fig. 26 represents what is known as a sheave wheel. The outer rims of such wheels are always of light construction with a heavy hub. Therefore, it becomes necessary to pour the molten steel rapidly into the mold, allowing full outlet for all gases formed. A bottom gate is provided on the hub.

Fig. 27 shows a small bevel gear cast with two side heads and one top head. This is a troublesome small casting to handle and the side heads, while not accepted as efficient, answer the purpose at hand.

Fig. 28 shows method of casting a small job, using a gate as a feeding head with a side riser connecting a heavy section.

Fig. 29 shows a method of molding and casting small plain jobs, readily mounted on boards for rapid production. Large sprues hold the castings together so as to feed them properly.

Fig. 30 represents a method of handling long, thin castings. It is very necessary in such work that all strain be removed at once from the casting. Therefore no gates or heads must be allowed to prevent the casting from shrinking.

Fig. 31 shows the amount of labor which must be expended on some jobs to produce solid castings, when they are made in jobbing shops. A head must be placed on every boss to insure a solid casting. The chill nails placed in the bottom bosses to assist solidity are clearly illustrated.

There are many more forms of castings which might be described but the foregoing will offer sufficient points for discussion. Today we steel foundrymen are more or less ignorant of our associates' practices. We must open up the gate in order to obtain more knowledge. This knowledge will lead us on to learn more, and through learning we can obtain some wisdom. Thus we may be able to develop a theory in relation to our practice.

---

It is sometimes stated that unless air is driven into the cupola with great velocity, it will not find its way to the centre of the fuel, but we believe this difficulty is greatly exaggerated. With few tuyeres of small area, which generally accompany high blast pressure, the danger of stoppage is obviously great. The way to ensure free entrance of the blast into a cupola is to increase the tuyeres in area and number, as there is less chance of a large opening becoming choked than a mall one, and six tuyeres becoming choked than three.

## HAMILTON NOTES.

The new Service Building that is being built for The Dominion Foundries & Steel by the Canadian Engineering & Contracting Co., Ltd., is progressing favorably, the main and first floors being completed and the second floor about ready to pour. A new entrance has been constructed for the employees with a better arrangement of the time clocks through a good building only recently completed. The old building through which the employees entered was more or less of a temporary one, and crowded in on the new service building.

The Dominion Foundries & Steel, Ltd., are getting well under way with a new plant at Albany. It is reported that this is to be a million dollar plant chiefly engaged in war order work.

zThe Frost Steel & Wire Co., Ltd., have large orders for telephone wire for Australia. The wire is being shipped to Melbourne, Australia, via Vancouver. The company have other large orders, and are very busy.

---

The foundries around Hamilton have large orders and are very busy. Orders, chiefly from the large manufacturing plants in and about the city, keep coming in almost faster than they can be filled. Some of the Foundries have orders taken before the moulders' strike still unfilled. Great difficulty is being experienced in getting and keeping men, especially helpers.

Labor conditions generally around the city seem to be getting more acute. There have been a number of strikes in different departments of the Steel Company of Canada. These have all been satisfactorily settled now, but large increases in wages have been given to quite a number of the men. Building contractors on various construction jobs for manufacturers are also having a good deal of trouble getting men, efforts have been made by some to bring in laborers from outside, but this does not seem to have relieved the situation to any extent. It is reported that 700 men from Hamilton have gone to the west harvesting.

Chinese are beginning to come more into use in the various iron and steel industries in this district. The Dominion Foundries & Steel have quite a number of them employed, and The Steel Company of Canada are beginning to use them also. They have been quite largely employed at Welland, and it is said they have given good satisfaction. They are slow but steady workers, and always keep at it.

The Manufacturers Gas Co. has officially notified the city of its action in turning over its assets to the Dominion Gas Co. and that it intends to surrender its charter. The Company has supplied gas to The Steel Co. of Canada, and a few other of the larger industries. It also is under contract to supply a fixed amount to the city free of charge and an additional amount at a reduced rate. It is understood the change will not affect the status of the city at all, as the Dominion Gas Co. also assumes the old company's obligations.

With increasing difficulty in obtaining gas or coal for manufacturing purposes, it is with much interest that the construction of a plant for the Imperial Oil Co. has been watched. The plant is located on Victoria Avenue N. It is connected to the water front with a series of underground pipes which can be fed directly from an oil tank steamer tied up at the wharf. Two large tanks have been installed at the new plant, one with a capacity of 50,000 barrels and the other of 35,000 barrels. The first oil tanker to deliver a cargo of oil to the new plant is the Imperial Oil Company's steamer "The Sarnolite." The boat called here on August 12th with about 20,000 barrels of oil. The oil can be delivered from the tanks to cars and so distributed wherever desired. Oil is coming more and more into use as a manufacturing fuel in these parts. The Dominion Foundries & Steel use it almost entirely for their heating furnaces. The Steel Co. are also using it, and making provision for its further use. The Hamilton Bridge Co. are quite large consumers as well as a large number of other companies in the city.

The Steel Company of Canada are putting in a new soaking pit at their blooming mill. This will be No. 5 Pit, two having been installed when the mill was built and an additional two when the new open hearth plant was put up. Alex. Laughlin & Co. are contractors for the new pits; this firm has done the greater part of the furnace work around the Steel Co. A new building will not be required, as the pit will simply follow after the present ones.

Mr. W. B. Champ, manager, and Mr. R. K. Palmer, chief engineer of the Hamilton Bridge Works Co., Ltd., attended the launching of the first vessel built by the American International Shipbuilding Corporation, at Hog Island, Pa., on August 5. The Bridge Co. have been very successful with their share of the steel fabrication for this work, indeed all concerned are to be very much congratulated on the great success of the whole undertaking.

Mr. W. M. Curry has resigned from the managership of the Burlington Steel Co. He has been succeeded by Mr. H. V. Hamilton, who for a number of years has been in charge of the Sales Department and also assistant manager. Before joining the staff of the Burlington Steel Co. Mr. Hamilton was on the sales staff of the Steel Co. of Canada. We wish Mr. Hamilton every success in his new position.

---

## NATIONAL STEEL IS TURNING OUT THOUSANDS OF CARS.

Recently, the last thirty-five cars of a contract for 4,000 cars ordered by the French government was shipped by the National Steel Car Company. After being set up the cars are taken apart, the parts numbered and crated. In France they are again assembled and the company has had a staff of over 100 men engaged in setting them up. The company has had a lot of difficulty in the carrying out of this contract, due to conditions over which it had no control. There was delay in getting material from the United States, and one shipment of 350 cars went to the bottom of the ocean, when a German U-boat sent a torpedo in the vessel carrying the big shipment.

At present the company is building 160 steel cars for the government of India. These cars also have to be taken apart for shipment, after photos are made showing where each part goes. As the Hindus or coolies used in assembling cars cannot read English, distinguishing marks are placed on the parts and these are shown on the photos.

Another contract in course of fulfillment is for 1,000 wheat cars for the C.N.R., which have been ordered by the Federal government for use this fall in removing grain from the west to the seaboard.

The company is at present making steel plates for the United States shipping board also.

## NATIONAL CAR PREPARING FOR AFTER THE WAR.

There is at least one big local industry that has turned out millions of dollars' worth of war orders that has already made preparations for peace conditions, by taking up a line that is not dependent on warring conditions, but that is required in this country for industrial purposes. This is the National Steel Car Co., whose plant in the past two years has had as many as 1,500 hands working there at once, and in the course of that period has turned out for one government—that of the republic of France—4,000 railway cars and 6,000 artillery trucks, and one of the peace products that it intends to feature is a motor truck. For some months its skilled engineers and mechanics, gathered together to take care of the immense war orders, have been working on models of trucks suitable for the work required of a motor truck in Canada, where the conditions are harder than in any other country, excepting that of Russia. The heavy snow and climatic conditions, sudden changes from heat to cold, in this land were such as to cause some cars that stood up well in other climates to fall down here, and that a truck of special construction was needed to meet the Canadian requirements.

The company's engineers are now satisfied that they have in the National truck a machine that will meet all requirements, and the company is confident, too—so confident, after tests of months on the road as well as in the factory, that the National trucks are now put on the market with iron-clad guarantees as to service and durability, and arrangements made for the immediate turning out of one hundred cars a month. Slight alterations have been made in the plant to care for this work, and as the business increases, as the officials believe it will, other changes will be made to increase the output.

One of the features of the National truck is the cone clutch, which was designed by one of the company's engineers, and patented by the company, and is a big factor in strength of the machine. The Detroit-Timken axles, which have been adopted by most of the members of the truck manufacturers' association of America, are used, and in the transmission Hyatt roller bearings are used throughout. The National truck is being made in four sizes—one ton, two ton, three and a half tons, and five tons. The company also is making a six ton tractor, and the model was used by the Hamilton works committee for some weeks in a test, which proved highly satisfactory to that body. It was used to haul five heavily laden garbage wagons from a central point to the city to dump at the bay. It is anticipated that these tractors will be used to a large extent in the motor freight traffic between cities in this vicinity. At present one freight and express operator on the Toronto-Hamilton highway has two trucks in commission, and has a third on order. Before cars are turned over to the dealer or purchaser, they are given a 350 mile test on the road and are given a special test on the Jolley Cut. They are taken up the mountain side loaded to the capacity which they are guaranteed to carry.

Service is the watchword of the National Company, which has a stock of parts for motor trucks that is not excelled in any plant in America, the sales manager claims. The smallest nut and the largest axle or motor is to be found in the stores department, which an inventory this week showed had $600,000 worth of goods on the racks. This means that there need be no delay on the part of any agent or truck owner in securing parts of a National truck, in case of accident. One of the conditions which the company imposes on all agents for the National is that they carry a line of parts.

The Mutual Motors Company, Main Street East and Catharine Street North, have secured the agency for the National in the district. Its service station is located on Catharine Street.

National Steel Car Co. tractors to be used for heavy duty hauling, as in lumber camps and for contractors, etc.—not for farm work. The firm expects to have a good exhibit in the Transportation Building at the Canadian National Exhibition in Toronto early in September. They are making a special point of truck work at this time.

The Hamilton Bridge Works Co. have about completed the addition they are putting up to their east-end shop, and hope to have it operating early in September. Both the east end and west end shops of the Hamilton Bridge Works are exceedingly busy. Some departments working day and night. There are quite a number of structural steel orders coming in, and the firm has contracts for ship work.

A branch of the Canadian Society of Civil Engineers has been formed in this city. A number of meetings have been held recently and officers have been appointed for the remainder of this year. Mr. Gray, city engineer, has been appointed chairman of the Executive Committee. About twenty-five members and associate members are resident in Hamilton.

The Canadian Cartridge Co., have received a third large order from the United States Government for cartridge cases for large size shells. This order will keep the firm busy for some months, day and night.

The National Abrasive Co., who recently arranged to leave Hamilton, have acquired twelve acres at Niagara Falls. Construction is being pushed on the work. Five furnaces are being installed at the present time, and it is expected this number may be doubled in the spring. The new plant will be over twice the size of the old one in Hamilton. The growth of the company is due to the increased use of abrasives, together with the difficulty of obtaining natural ones. The artificial abrasives are also considered better for some purposes.

The Brown Boggs Co., Ltd., machinists and foundrymen are putting up an addition to their foundry at their Sherman Avenue plant. This will be used for pattern storage. It is a fireproof building about 40 ft. x 90 ft.

The Acme Stamp and Tool Co. are putting up a good-sized building at their plant on Sydney Street. This is to take care of an overflow of work from their present plant and provide accommodation for the Alith Manufacturing Co., Bay Street, with which company they have been amalgamated for a number of years. They now expect to bring the two plants together.

The Burlington Steel Co., Sherman Ave., is putting up an addition to their shipping department. The new building will run south from the present shipping building, and will give them considerably more room.

## THE CANADIAN NATIONAL EXHIBITION FROM AN IRON AND STEEL VIEWPOINT.

### Hiram Walker & Sons Metal Products, Limited, Walkerville, Ont.

An exhibit of special interest to the readers of Iron & Steel of Canada was that of Hiram Walker & Sons, Limited (formerly Canadian Hoskins, Limited) of Walkerville, Ont., who exhibited a splendid line of electric and gas furnaces, pyrometers, pyrometer couples, and laboratory apparatus. One of the features of their exhibit was their Nichroloy non-ferrous alloy, which possesses marked non-corrosive properties, especially under the influence of heat. These properties are due to the high melting point of chromium, combined with the high resistance of nickel to oxidation. This metal does not soften under heat as does cast-iron, and under usage last 40 times as long.

### Main Beltings Co. of Canada, Limited, Montreal and Toronto.

Mr. S. R. Walsh, the Ontario representative of this well-known Montreal house, was found again at the old stand in Machinery Hall, with a splendid display of their Leviathan and Anaconda beltings, adaptable both for power transmission and conveyor purposes. Belting 80 inches wide and 300 feet run formed one of the interesting parts of the exhibit. These belts are especially adaptable to use in the iron and steel industry, and a large number are now to be found in the leading plants throughout the Dominion.

### Pratt & Whitney, Limited, Dundas, Ont.

The skilled mechanic and tool maker found a splendid exhibit of Canadian made cutters, reamers, taps, drills, shell tools, etc., in the attractive exhibit of this firm, who every year are to be found with a fine exhibit of these lines in the Machinery Hall. Pratt & Whitney maintain a most modern factory at Dundas, Ont., where these lines are manufactured.

### Baines & Peckover, Toronto.

A splendid exhibit of concrete reinforcements was featured by this firm in the Machinery Hall. In a model built in their exhibit the steel reinforcements and the tie chains and bar ties were shown to good advantage. Faralun anti-slip treads were built in the steps, and a feralun plate and coal hole cover were exhibited as well. This product is formed by the incorporation of an abrasive substance into the iron body of the tread, and the resulting surface prevents one of the most common causes of accidents, that of falling on the stairs and slipping on a smooth cast-iron surface. Steel Crete expanded metal machine guards, together with a splendid display of Triumph Suburb High-speed Tool Steel, Cold Drawn and Nickel Steel bars were also featured.

### L'Air Liquide Society, Montreal and Toronto.

At the Toronto plant of this company a school for the instruction of the returned soldier in the art of welding and cutting metals is now being carried on, at the company's expense, in the material used and the instructions given. This course lasts six months, and is proving of splendid use to many of our returned men. Welding is now being used extensively in all branches of the iron and steel industry, and is practically indispensable. A standard line of oxyacetylene welding and cutting apparatus was shown by the L'Air Liquide Society in Machinery Hall.

### Stellite.

Since Stellite has been put on the market by the Deloro Smelting and Refining Company, Limited, many indispensable uses have been found for this now well-known metal. A recently discovered use for Stellite is in the making of sand blast nozzles, which will prove of great interest to readers of Iron and Steel of Canada. The nozzles formerly used lasted for continuous work for about two hours, but the manufacture of Stellite claim for nozzles used from their metal a life of at least two weeks with continuous use, this being secured through the extreme hardness of the metal used. Stellite is now being used in the manufacture of formed tools of all shapes, which are readily cast in such a manner that very little grinding or finishing is required. One of the displays of this interesting exhibit was a line of welded cutters, the cutters shown being stocking cutters used by the Hamilton Gear & Machine Company in operations on gear wheels. These welded cutters are formed of a soft steel centre, on which cutting edges of Stellite are welded by the oxywelding process. Built-up cutters were also shown, the inserted plates of Stellite being fastened to the steel centre by the usual methods.

### The Perfect Machinery Company, Galt.

The Perfect Machinery Company, had a display of gear-driven, and sensitive drills, a full line of grinders equipped with both machine guards and exhaust hoods. Three types of hacksaws for various purposes were shown, and an 18-inch double back geared quick change gear. 12-inch and 14-inch lathes, suitable for garage or engine work were also shown. These lathes are an example of accurate high grade workmanship and convenient design.

### The Canadian S.K.F. Company, Toronto. .

The S. K. F. self-lining tool bearings and Hess Bright tool and press bearings formed the exhibit of this well-known company. Working models were shown in operation and a loaded friction demonstration apparatus showed the comparative ease in operation of the tool bearing over the ordinary journal. The company was represented at the exhibit by Messrs. Gordon James, H. N. Trumbull, A. G. Webster, H. Brown, and Drummond Giles.

### Dunlop Tire and Rubber Goods Co., Ltd., Toronto.

A feature of this company's exhibit was their Gibraltar Red Friction cover belt, which is adaptable to the belting needs of the iron and steel industry. This belt is made of heavy canvas duck, impregnated with very heavy friction. Valve disc holes for industrial purposes and the Gibraltar Red Pneumatic tool holes, adaptable to the shipbuilding industry, were also shown. The whole exhibit was in charge of Mr. H. C. Austen.

### Garlock Walker Machinery Co., Ltd., Toronto.

In the Machinery Hall this well-known machinery house displayed a full line of metal working and woodworking machinery, a number of these lines being especially adapted to the shipbuilding industry. The Lodge and Shipley 20-inch selected head engine lathe was shown in active operation. This lathe is designed for quantity production, and the mechanical arrangement is perfect.

### Dodge Mfg. Company, Limited, Toronto.

An active demonstration of the manufacture of the Dodge Wood Split Pulley was shown this year in the Machinery Hall. The method of joining segments by means of dove-tailed glued joints, the building up of the laminations into the completed rim, and the method of attaching the pulley arms to the rim was clearly shown. The construction adopted permits the turn-

ing of the inside of the rim. The rim is finished with a special filler and varnish, which secure a very durable surface, and one which reduces belt slipping to a minimum. In addition to their tool display the company also showed their full line of Standard Transmission machinery.

### The Chapman Double Ball Bearing Co. of Canada, Limited, Toronto.

In addition to their ball-bearing shaft hangers and their well-known bearings, and bearings for all sizes of shaftings up to 6 inches, this company exhibited a line of annular and thrust bearings for machinery, automobiles and trucks, which is a new development for this concern. Various sizes of the Universal truck for industrial and shop use were also shown. During the last several years the development of this company's business has been so great that to take care of their tremendous American trade, the company have established a large and modern plant at Buffalo, which is now working to full capacity to take care of their American business. The headquarters of this concern is in Toronto.

### A. R. Williams Machinery Company, Limited, Toronto.

Practically everything in the line of iron and woodworking machinery and tools was to be found in the extensive exhibit of this firm this year. Particular interest was shown in the display of machinery adaptable to shipbuilding interests. A 36-inch Preston Bandsaw and a 24-inch Eclipse plainer were exhibited, together with a variety of tilting saw tables and a self-feeding ripsaw, made by the Preston Machinery Company of Preston, Ont., and sold by this company. The exhibit was in the care of Mr. Cronk, the representative of the company.

### The Prest-O-Lite Co., Inc., Toronto.

An exhibit comprised of the various welding and cutting torches, manufactured by this firm, was shown in Machinery Hall. One of the features was the demonstration of the use of dissolved acetylene for welding purposes, showing the convenience of this apparatus for lighting large areas where construction work is being carried on. This company have recently constructed a large factory in Toronto to take care of Canadian trade.

### D. K. McLaren, Limited, Montreal and Toronto.

The exhibit was in charge of Mr. W. S. Hamilton, their sales manager, and, in addition to their textile supplies was seen their line of single and double leather belting and wood split pulleys. This firm are also sole Canadian selling agents for the Phillips pressed steel split pulley, which was shown in the exhibit.

### The Independent Pneumatic Tool Company.

The Independent Pneumatic Tool Company, manufacturers of Thor tools, were represented by Mr. W. H. Rosevear, Canadian manager, and Mr. Gordon McCrea, Ontario manager. The various types of riveting and chipping hammers and drills were shown in operation and an exhibit of the tools in sectional form shows the complete mechanism to advantage.

### The Carter Welding Company, Toronto.

The Carter Welding Company showed the Beck-Todd spacing machine, a Canadian invention, used for the elimination of recuts in nicking shell steel. This machine, by a suitable mechanism, divides the bar steel into a desired number of pieces, all of equal length, no matter what the length of the steel bar may be. By achieving this result no recutting of the last billet is

# EDITORIAL

## EDUCATION.

A series of very interesting and somewhat revolutionary papers by Mr. C. V. Corless appeared in the Monthly Bulletins of the Canadian Mining Institute beginning last December. In substance, the writer draws attention to the undeniable fact that education should be designed to teach young people how to live and not merely to teach them to read and write and to develop their literary abilities.

He urges that children and young people should be taught directly by means of things, in which they are naturally interested, instead of in the usual way by learning out of books, which they naturally detest. Reading, writing and arithmetic must be taught, of course, but they should be regarded as means to an end, not as an end in themselves. The education contemplated is, on the other hand, not merely a technical training designed to teach a trade, but is a broad education based on first hand observation of the things which lie naturally to hand, and in which the young citizen of any country should have the greatest interest.

We realise the need of proper education at the present time even more than in the past, in view of the startling changes which have taken place in the social edifice of every nation. It is quite clear that the reconstruction which is to take place after the war, and which is taking place at the present time, can only lead to satisfactory results if the people constituting each nation are fully informed not only with regard to their rights, which has been a watchword in the past, but even more with respect to their duties to society, which we hope will be the keynote of the future. Education along these lines would be given, according to Mr. Corless, not by reading maxims out of books or committing to heart verbal generalities, but by practical instruction in the elementary duties of citizens in regard to their home, village or city, which would develop naturally into their relation to their country and to the whole world.

It cannot be questioned that the elementary education at the present time is lacking in a great many particulars, but it is, of course, open to question how far the ideals of Mr. Corless can practically be worked out in view of the limited conditions under which we live, and in view of the present attainments of the teachers who have to administer this education.

The subject is, however, one of the first importance at the present time, and we are glad to learn that something is beng started with a view to remedying present conditions. A meeting was held in Ottawa on September 20th under the auspices of the Canadian Mining Institute for the consideration of needed reform in the matter of common school and technical education in the Dominion of Canada. Dr. W. L. Goodwin was elected Chairman of the meeting and Mr. G. M. Stephenson was Secretary. An interesting discussion was held, and a committee appointed to consider the situation and present some definite scheme of reform to the educational authorities. We hope to give further particulars of this movement at a future date.

## NEED OF COLLEGE STUDENTS.

In Canada among the first to respond to the call of duty at the beginning of the war were the college students, who flocked in large numbers to the colours and left the halls of learning largely deserted. The same thing has taken place in England, where Oxford and Cambridge are almost empty.

The result of this has been in some measure disastrous; as although these men were undoubtedly the finest obtainable for building up the new army which was so urgently needed; their departure to the front has left a gap which it is practically impossible to fill.

In the United States the need of military service has been somewhat less urgent than here, and they have therefore been able to consider the matter somewhat more carefully and have made a very desirable arrangement whereby the students in chemistry and other branches of applied science, as well as the medical and dental students, who have been drafted for military service, are sent back to complete their educational courses while remaining in the Government employ and subject to recall in case of emergency. The students wear their uniforms and receive their regular military pay, while they are serving the country by acquiring the necessary education.

It is interesting to note the recognition by the American authorities of the extreme importance to the nation of technically trained college men, and it seems probable that similar arrangements will soon be made in this country, so that after the war we shall not be left entirely without young men with a technical training suitable for conducting the metallurgical and chemical industries of this country.

## MONTREAL METALLURGICAL ASSOCIATION.

By the time this paper has been printed the first meeting of the Association will have been held on Tuesday, the eighth of October in the Chemistry Building of the McGill University. The subject of the evening is to be a discussion of the critical point in steel. This discussion will be taken part in by a number of technical men, and their addresses will be illustrated by lantern slides showing the importance of this point or change in regard to the microscopic and consequently the physical properties of steel. The existence of the critical point will be demonstrated by scientific apparatus in the lecture room, and its meaning and importance will be fully brought home to all who are able to be present.

We take this opportunity of mentioning that, owing to the interference of another course of lectures, it has been found necessary to change the date of the meetings, which will in future be held on the second Tuesday in each month.

The following meeting is to be held on Tuesday, the 12th of November, and it is hoped that on that occasion the Association will be addressed by Professor N. N. Evans on Chemical Signs and Equations. This subject, which may appear dry at first sight, has been introduced to meet the difficulty felt by many who have not had a college education, in understanding the meaning of those symbols and equations which are necessarily used by many of the speakers at these meetings. Professor Evans is a very capable, not to say amusing lecturer, and any who can be present on this occasion need not fear that the address will be in any sense "dry."

## LECTURES ON IRON AND STEEL METALLURGY.

A course of lectures by Mr. W. G. Dauncey on this subject will be held on Thursday evenings during the winter months. The first lecture will be on Thursday, November 7th. Lectures will be given in the Chemistry Building of McGill University and will commence at eight o'clock each evening. The fee for the course is five dollars, which is payable in advance to the Bursar of McGill University, who will furnish a ticket for admission.

The subject matter of the course was outlined in the last number of "Iron and Steel," and we confidently recommend them to any who wish to increase their knowledge of this important and interesting subject.

## CONSOLIDATED MINING AND SMELTING COMPANY.

Many of our readers will have noticed that early in September a part of the smelting plant at Trail, British Columbia, was destroyed by fire; the damage being estimated at between forty thousand and fifty thousand dollars.

It appears that the roasting plant was burnt down owing to the ignition of some oil. This unfortunate accident must interfere for some time with the output of zinc from this plant, as the roasting operation is part of the process for producing zinc from the complex Sullivan ores by the electrolytic method.

## CHANGE OF OFFICE.

The present number is the last which will issue from the office of the Industrial and Educational Press at 45 St. Alexander Street, Montreal. The November number will be brought out from the new plant which has been erected at Ste. Anne de Bellevue, Que.

Dr. Stansfield, the Editor of "Iron and Steel," will, however, remain at his office in McGill University, and takes this opportunity of requesting that contributions and other matters for the editorial staff shall be sent to him personally at that address, and adds that his telephone number is Uptown 5920.

## MESSRS. ARMSTRONG, WHITWORTH OF CANADA, LIMITED.

In our September issue we editorially dealt with the manufacture and uses of Alloy Steels, more particularly as an after the war problem. Since then we have had an opportunity of learning something of the work that is being done at the Longueuil Plant of the above mentioned firm, Considered as a manufacturing proposition the undertaking is only in its infancy, the official opening having taken place as recently as December, 1914. At that date six coke crucible holes had to take care of the steel production, and the hammer, furnace and repair shop equipment was on a very small scale, whilst the tool room capacity was barely 30 per cent. of what it is to-day. Since then following the progressive policy of the Managing Director—Mr. M. J. Butler—development has been rapid, and in addition to the crucible department four electric and two open hearth furnaces have been installed, and steel is now being produced ranging from straight carbon up to complex high speed and special alloy, the former for munition work and the latter in answer to the growing demand for a steel that shall possess unusual, or intensified, physical characteristics. The firm also has the credit for having installed the first mill in Canada for rolling railway tyres, and having overcome the initial difficulties incidental to such an undertaking are now producing tyres up to 72 inches in diameter not only for Canadian requirements, but for demands outside of the Dominion. Judging from all available indications, this department will have a busy future, for owing to abnormal war conditions, the production of rolling stock has, during the last few years, been seriously curtailed. In a plant such as this heat is the most important factor, for it is not only essential for production, but has to be relied upon for annealing and hardening as well as for the special treatments called for by the higher grades of steel. Mr. Butler has been identified with

many efforts to secure greater heat efficiency in manufacturing industries, and has put in a modern plant for the utilization of powdered coal wherever possible, and experiments are now being carried out which, there is every reason to believe, will demonstrate the economic possibility of adopting this fuel for open-hearth steel production. At some later date we shall be able to give the results of these experiments in detail, for we have been given this permission, which is only held in abeyance until some definite results have been obtained. It is probable that some modifications in detail design of furnace may be necessary, and changes in slag pockets and regenerators may have to be made, but apparently these will only be of a minor nature. The powdered coal yields an intensely hot flame, is easily regulated, and under proper conditions need not be dirtier than oil or producer-gas, but owing to the danger of choking the chequers a coal low in ash is essential. However, the experimental work along these lines is being closely watched by men engaged in the production of steel, and we are glad to assure our readers that we shall be able to supply figures so that a comparison may be made between the cost of producing open-hearth steel by means of powdered coal and oil. War conditions in metallurgical practice as in all other manufacturing industries, and to-day basic open-hearth steel is being made at Messrs. Armstrong Whitworth's plant without the addition of either pig or cast iron. Two methods were tried out, one of which introduced the necessary carbon for chemical reactions into the furnace, and then carburized back to the specification, .45—.55 carbon in the ladle, and the other aimed at introducing sufficient carbon for all purposes into the bath. Both methods proved successful, but the introduction of a large percentage of carbon into a ladle gave wild metal, and caused a good deal of slopping, and to obviate this trouble the second practice was adopted. Once melters get used to the conditions there is no difficulty, but these gentlemen are usually of very conservative dispositions, and will raise innumerable objections when asked to work a heat that will finish around .08 or .06 carbon, but has to be brought back to .45—.55 carbon by the addition of carburizing materials in the ladle. The general scheme and policy of those directing the development of this plant is to prepare for after the war conditions, although not neglecting to assist in the production of steel for munition purposes in the meantime. Mr. M. J. Butler is at the head as Managing Director; Mr. Laurence Russel is his assistant, and also acts as Secretary Treasurer, and Mr. Herbert Johnson is General Superintendent of the works.

---

# The Briquetting of Lignites

Extracts from the Report of R. A. ROSS, E.E.,
Ottawa, 1918.

**Introduction.**

Although the fuel resources of Canada are enormous and varied, their geographical distribution is such as to leave the region between the Atlantic bituminous coal deposits and the lignite deposits of Saskatchewan destitute of all natural fuels save peat and wood.* Hence the Provinces of Quebec, Ontario and Manitoba must be supplied in large part by importations from the United States, supplemented by shipments from the Eastern and Western Canadian coal areas. High freight rates are an inevitable concomitant of this condition.

As more than half the coal used in Canada is imported from the United States, and as nearly all is used in this naturally coalless region, our dependence upon the United States constitutes at once an industrial menace and a national problem. Fortunately this problem is capable of solution. Superabundant unutilized water powers can provide ample energy for industrial requirements in Eastern and Central Canada. Farther west the feasibility of meeting requirements in Saskatchewan and Manitoba by utilizing prepared lignites and sub-bituminous coals is the subject of this report.

**The Situation.**

1st. The fuel resources of the Dominion of Canada are second only to those of the United States, the greatest coal country in the world.

2nd. In spite of this fact, Canada imports at present and always has imported—50 per cent of her fuel from the United States.

3rd. Canadian efficiency in this regard is, therefore, about 50 per cent.

4th. Under these conditions the problem must be attacked, preferably by the Government, and not by isolated commercial agencies working in competition with each other.

5th. An examination of the map attached will show the Canadian territories supplied by coal distributed from various centres and indicate an immense area whose requirements are met from American sources.

6th. The province of Saskatchewan, as will be seen, is the balancing point for fuel from the East and from the West, and for this reason fuel prices are the highest, although underlying a great part of this province are immense deposits of lignite awaiting use.

7th. We, therefore, recommend that the attack on the fuel problem of Canada be concentrated first on the production of domestic fuel from the lignites of Saskatchewan for the following reasons:

(a) Because the price of anthracite coal in normal times in this district is the highest and runs about \$15.00 per ton.

(b) Because successful briquetting of the lignites of Southern Saskatchewan will also solve the problem of briquetting the higher grade lignites of Alberta.

**The Lignites.**

Coals for commercial purposes are arbitrarily grouped as follows: Anthracite, semi-anthracite, bitumin-

---

*Natural gas and petroleum are relatively of minor commercial importance.

ous, semi-bituminous, and lignite. All of these are available in this country in greater or less degree.

The manufacture of the lignites into briquettes in the manner proposed constitutes an artificial method of raising a very low grade fuel to the highest grade with the production of gas and other valuable by-products, no allowance for which is made herein.

1st. Various grades of coal, from anthracite in the rockies to poor lignites in Southern Saskatchewan underlie a large part of the provinces of Alberta and Saskatchewan, whereas further East we have no coal deposits until the Maritime Provinces are reached.

2nd. The raw lignites of Southern Saskatchewán when taken from the ground contain about 40 per cent of water which must be eliminated by air-drying or evaporated in the furnace at the expense of the heat value of the fuel.

3rd. This condition renders the raw fuel unsatisfactory for domestic use, both on account of the cost of transporting the water and of its evaporation. The fuel is impure, falls to pieces if stored, and can only be utilized when freshly mined.

4th. Examination of Table 8 will indicate the relative positions of lignite as mined, briquettes of carbonised lignite, and anthracite, in the scale of heating values. When the other factors of operation, such as loss through grates, etc., are considered, it is safe to say that the heating value of the lignite as mined is increased 100 per cent by carbonizing and briquetting.

5th. Raw lignites are briquetted commercially in Germany, but so far it has not been found possible to handle the lignites of North Dakota and Saskatchewan in this way, nor in view of the situation to-day is it advisable to do so even if it were possible.

6th. By corbonizing the lignite a coke or charcoal is obtained which briquettes readily, has a high heat value, and by-products such as tar, ammonium, sulphate, gas, etc., are recovered.

7th. Without consideration of the by-products the result has been to turn two (2) tons of poor fuel into one (1) ton of fuel approximating anthracite in caloric value with practically the same actual heating value in the domestic furnace as the two (2) original tons from which it was made.

8th. After carbonizing, briquetting can only take place through the agency of a binder for which coal-tar pitch and sulphite pitch have been successfully used. Sulphite pitch, a waste product from pulp mills, is available in immense quantities. The only purpose which it subserves at the present time is that of poisoning fish in the various waters near which pulp mills are situated.

9th. After carbonizing and briquetting, the fuel must be waterproofed. This is accomplished by a simple heat process resulting in the coking of the binder.

### Present State of the Art of Producing Carbonized Lignite Briquettes.

The processes involved in the manufacture of carbonized lignite briquettes have all been carried to a stage beyond that of the laboratory. The next step forward involves commercial methods of production on a scale sufficient to demonstrate the best production methods and the costs.

1st. Briquetting of the raw lignites of Central Europe, especially those of Germany, has been carried on successfully for years past, the output for 1913 in Germany being 20,000,000 tons.

2nd. The briquetting of bituminous slacks and small sizes is carried on in several parts of the United States in a commercial way at the present time.

3rd. The briquetting of anthracite slack in British Columbia has been a practical success for some years past, both for domestic and locomotive fuel.

4th. The carbonising of North Dakota lignites has been carried on at Hebron, N.D., in a semi-commercial way, and carbonized Souris lignite has been produced at Estevan on a small scale.

5th. The briquetting of these lignites, however, has not been carried on in a commercial way, any briquettes made being produced sporadically in carload lots, sufficient in amount only to demonstrate that briquetting is practicable.

6th. Carbonizing is a simple process and sufficient information and experience has been obtained to warrant commercial production.

7th. Briquetting and suitable binders require study upon a commercial scale in order to determine temperatures, pressures, mixtures and results in actual practice.

8th. The necessary waterproofing, which is obtained by a heat treatment of the completed briquettes, presents no difficulty whatever, being a simple matter of coking the binder at a low heat.

9th. Summing up, the producer must face the difficulties inherent in commercial production which are approximately of the same order as those met in other industrial establishments. The problem has been solved; it remains merely to overcome the incidental difficulties.

10th. The road to success in the briquetting problem is strewn with the wrecks of ill-conceived attempts to do this apparently simple thing—failure resulting from either lack of knowledge of what had been done, lack of technical experience, or shortage of money.

11th. For the above reasons, amongst others, private capital is chary of such enterprises. It is argued that the chances of failure are great, and, as the market cannot be cornered, any process when successfully developed will be utilized without cost by competitors. The situation in Saskatchewan, therefore, should be grappled by the Government.

12th. Thereafter the business may be continued by the Government as a public utility, or, as demonstration having been made and results shown, private investors may confidently venture.

---

In 1913 Germany used 28,600,000 tons of iron ore and 21,000,000 tons of this was mined in Lorraine. Excluding French territory now held, Germany possesses more than half the coal resources of all Europe.

---

It is a fundamental fact that results obtained with any combination having iron as its base will be in direct proportion to the amount of phosphorous and sulphur present.

# Why Busy Rails Do Not Rust[1]

By OLIVER P. WATTS.[2]

A paper read before the American Electro-Chemical Society, May, 1918.

It is a common observation that rails in the main line of a railroad never rust seriously, although those made of the same material but laid in a siding where there is little or no traffic, are soon badly rusted.

The observation of this phenomenon dates back to the infancy of the railroad. Robert Mallet[3] quotes a report of George Stephenson as follows: "One phenomenon in the difference of the tendency to rust between wrought iron laid down as rails, and subjected to continual motion by the passage of the carriages over them, and bars of the same material either standing upright, or laid down without being used at all, is very extraordinary. A railway bar of wrought iron laid carelessly upon the ground alongside of one in the railway in use, shows the effect of rusting in a very distinct manner: the former will be continually throwing off scales of oxidated iron, while the latter is scarcely at all affected.'

In commenting on this observation of Stephenson, Mallet says, "When rails lying parallel on the same line of way, but one set in and the other out of use, are examined, appearances do undoubtedly seem to support the opinion. The unused rails are found covered with red rust, often coming off in scales parallel to the surface, while those in use present a light brown or buffish coat of rust, without any loose scales. I am much disposed, however, to believe that there is no real difference in the amount of corrosion in the two cases, and that the difference in appearance arises partly from a deceptio visus, by the effect of the bright and polished upper face of the used rail (kept so by constant traffic) contrasted with the rusty face of the unused rail, and partly from the fact, that as fast as rust is formed upon the rail in use, it is shaken off by the vibration of passing trains and blown away by the draft of wind which accompanies their motion, and that the rail is soiled and partially blackened by coke and other dust, etc."

From 1842 to 1849 Mallet[4] conducted three series of experiments with full-sized rails, each series comprising rails laid in the track, others laid beside those in use but not traveled over, and still others laid in the track but protected from atmospheric oxidation by a coating of tar. After making allowance for losses by abrasion, he reported the loss by corrosion in grains avoirdupois per square foot per year to be as follows:

| | 1st Exp. | 2nd Exp. | 3rd Exp. |
|---|---|---|---|
| Time in Days. | 303 | 730 | 1460 |
| Rail idle . . . . . . . . . . . | 213.38 | 76.00 | 96.18 |
| Rail in use . . . . . . . . . . . | 103.04 | 32.87 | 83.53 |
| Difference . . . . . . . . . . . | 110.34 | 33.13 | 12.65 |

Mallet assumed that the top of traveled rails did not corrode, and hence omitted the area of the top in reckoning the surface of used rails. A recalculation of his results on the basis of the total surface of used rails gives 87.30, 27.85, and 70.77 for the losses of rails in use instead of the values published by Mallet; the corresponding difference in corrosion of idle and busy rails are 126.08, 48.15, and 25.41 grains per square foot per year. It is noteworthy that the longer the period of exposure, the less the difference between the corrosion of busy and idle rails. This will be referred to again later. In explanation of the different rates of corrosion Mallet calls attention to the fact that "every metal is electropositive to its own oxide," and says, "Now the rust formed upon a railway bar in use is perpetually shaken off by the vibration of traffic, and thus this source of increased chemical action is removed."

W. H. Barlow[5] in 1868 comments on the phenomenon as follows: "The great difference between the effects upon rails laid in a siding and rails laid in the main line was, that the one by the wear of traffic had a polished surface, and the other had not; and he thought it quite possible that a galvanic action arose between the polished and the unpolished surfaces, which tended to preserve the general body of the rail."

Cushman, Friend, and Sang, in their books on the corrosion of iron[6] call attention to this comparative freedom from rust of busy rails, and suggest various explanations for it. Sang says, "Galvanic action between the smooth head of the rail and the rest of it has been suggested to explain this immunity from rust, but it is not at all likely that the foot would owe its protection to the thin stratum of denser metal so far removed from it. If that dense skin on the top of the rail were not crushed beyond its elastic limit, it would, on the contrary, tend to accelerate the corrosion of the steel in contact with it. The real reason for this difference of behavior seems to lie in the observed fact that oxidation is apparently arrested, or at least greatly retarded, by vibration. Explanations seem to stop at this point, but a simple theory can be built on the assumption that the vibration causes a shedding of the

---

[1] Manuscript received March 4, 1918.

[2] Assistant Professor of Chemical Engineering, University of Wisconsin.

[3] Report of Brit. Assoc. for the Advancement of Science, 1843, p. 28.

[4] Report Brit. Assoc. for Advancement of Science, 1849, 88.

[5] Proc. Inst. Civil Eng., 27, 570.

[6] Cushman: Corrosion and Preservation of Iron and Steel, 1910, p. 108.

Friend: Corrosion of Iron and Steel, 1911, pp. 99, 118, 247.

Sang: Corrosion of Iron and Steel, 1910, p. 71.

rust as soon as it is formed on the spots that are not protected by mill scale, and there is, therefore, no acceleration of the action due to the accumulation of spongy and electro-negative rust."

Commenting on the above explanation, Friend says, "No doubt this is a partial explanation, but the freedom from rapid rusting may be due in part to the rise in temperature caused by the rush of trains over the metals, whereby the rails are maintained at a temperature slightly above that of their surroundings. The result is that liquid water has no good opportunity of condensing upon them, or, if once condensed, it is rapidly vaporized and corrosion retarded."

Cushman ascribes protection to "the fact that frequent and recurring vibration was sufficient to break up points of specific potential differences on the surface."

The idea that rails in constant use owe their immunity to rust to galvanic action between the strained and unstrained metal does not at present seem to be accepted. This is perhaps not strange, for until comparatively recently[7] it had not been surely demonstrated by experiment that cold-working renders iron electro-positive, and it was also generally held that the E. M. F. between strained and unstrained iron or steel, granting that a difference of potential exists, is too small to exert a protective effect on the rest of the rail, especially on those parts which are several inches distant from the head of the rail.

Believing galvanic action to be chiefly responsible for the observed difference between the rusting of used and idle rails, the writer endeavored to ascertain if the head of a used rail is really positive to the remainder of the rail, a point which seems to have been left undetermined so far in the discussion of this question. Through the kindness of Mr. G. N. Prentiss, chemist for the Chicago, Milwaukee & St. Paul R. R., a section of used rail was secured. Pieces were cut from the top and the bottom, and covered with paraffine except for one side, so that the exposed surfaces should be approximately equal and that on the piece from the top only the worn surface of the rail should make contact with the electrolyte. The E.M.F. between these pieces was measured in normal potassium chloride by means of a potentiometer. The initial voltage was 0.078 volt, rising in five minutes to a maximum of 0.084, from which value it slowly fell to 0.029 at the end of an hour, during which time the electrodes were not moved. On shaking both electrodes the E.M.F. rose to 0.056, but dropped in 3 minutes to 0.037. The potential measured by a milli-voltmeter of 16 ohms resistance immediately after the last reading by the potentiometer was only 0.015, which fell in 2 seconds to 0.005 volt. A millivoltmeter is unsuited for reading the E. M. F. between electrodes of such small surface as these, viz., 6 sq. cm.

Instead of removing any slight differences of potential that naturally exist on the surface of the rail, as was contended by one of the authorities on corrosion previously referred to, the passage of trains develops a difference of potential exceeding 80 millivolts, between the upper surface and the rest of the rail. The question now is: To what extent is this E. M. F. responsible for the lessened corrosion of busy rails?

The prevention of the corrosion of iron by connecting the metal as cathode and sending current to it from a source of E. M. F. outside of the corroding solution has been the subject of several investigations, and this principle is the basis of a number of patented processes for preventing the deterioration of metals and alloys when exposed to severe corrosive conditions. Gee[8] found 0.088 ampere per square foot (1 sq. meter to be more than sufficient to protect iron from corrosion in 1 per cent sodium chloride solution. Harker and McNamara[9] found 0.004 ampere per square foot (0.044 per sq. m.) to be sufficient to prevent the corrosion of iron in sea water, and Clement and Walker[10] obtained the same result by using a current density of 0.11 ampere per square foot in N/100 sulphuric acid. In the Cumberland process for preventing the corrosion of boilers 0.001 ampere per square foot (0.011 per sq. m.) has proved sufficient for the purpose.[8].

That the E. M. F. between strained and unstrained iron is great enough to cause selective corrosion in dilute acids was conclusively proved by the experiments of Burgess and Thickens previously referred to. In view of the small current density that was found to prevent corrosion of iron under the severe conditions of immersion in sea water, it is to be expected that the strained condition of the upper surface of used rails will exert a considerable protection action on the rest of the rail when the electrolyte is so slightly corrosive as is the dew or rain water which wets the rails. It might seem therefore, that the whole matter has been cleared up· but while the formation of a local couple by contact of two dissimilar metals in an electrolyte lessens the corrosion of the cathode, the rate of corrosion of the anode is thereby increased, and the question arises whether or not the total loss in weight of both materials is increased or diminished by putting them in contact.

To determine this a bar of mild steel (about 0.4 per cent C) ¾ in. (1.9 cm.) square and 4 inches (19 cm.) long, was machined in a lathe to a diameter of ⅝ in. (1.6 cm.) for a distance of an inch (2.5 cm.) in the middle of the bar, leaving the ends unchanged. The bar was then twisted through 180 deg. in a testing machine, by which a local couple having an E. M. F. of 80 millivolts was formed between the cold-worked middle and the unstrained ends. The bar was then machined to a diameter of 0.563 in. (1.4 cm.) throughout its entire length. A similar cylinder was prepared from unstrained metal, and the two were immersed to a depth of 3¾ inches (8.2 cm.) in N/5 hydrochloric acid for 72 hours. After cleaning, drying, and weighing, it was found that the bar in which the local couple had been formed by cold-working had lost 6.768 grams, while the other had lost only 5.436 grams. This means that the efficiency of cathodic protection by the current generated by the local couple was much less than 100 per cent; at an efficiency of 100 per cent the excessive corrosion of the anodic portion of the bar caused by the voltaic action would have been exactly counterbalanced by the protective effect on the cathodic portions, and the loss in weight of this specimen would have been the same as that of the unstrained metal.

---

[7] Burgess and Thickens: Tr. Amer. Electrochem. Soc., 1908, 13, 31.

[8] Trans. Faraday Soc., 1913, 9, 120.

[9] J. Soc. Chem. Ind., 1910, 29, 1286.

[10] Trans. Amer. Electrochem. Soc. 1912, 22, 193.

In acid of the same strength as that used in this experiment, and also in sea water, Harker and McNamara found that the corrosion of zinc or iron which naturally occurred in these solutions could be overcome by inserting an anode of the same metal and making the corroding metal cathode, while passing a current exactly equivalent to the amount of metal previously lost. Clement and Walker reported the same condition to hold with regard to the protection of iron in N/100 sulphuric acid even when an insoluble anode was employed, i. e., the efficiency of cathodic protection is 100 per cent when the source of E. M. F. which produces the current is situated outside of the corroding solution. The low efficiency of protection found by the writer in the case of strained versus unstrained iron, corresponds to the wasting of an unamalgamated zinc in a voltaic cell with an acid electrolyte. In neutral electrolytes, as when rails are laid in a track, a high efficiency of protection is to be expected, just as there is a high efficiency of utilization of an unamalgamated zinc anode in neutral electrolytes.

Mallet's experiments on the rusting of used and idle rails showed an apparent efficiency for the protective action greatly in excess of 100 per cent. It is of course impossible that this can be directly due to the protective effect of current flowing from the head of the rail, but it is a simple matter to find a logical explanation for it. As has already been indicated, it is generally recognized that the presence of rust is a stimulator to further rusting, and that the thickness, age and porosity of the rust are factors of importance in determining the rate at which rusting proceeds. Traffic keeps bright the upper surface of the rail, where the coat of rust would otherwise be heaviest, and the current flowing from this lessens the thickness, and probably modifies the quality of the coat of rust on other parts of the rail; the result must be a slower accumulation of rust on used than on idle rails (meaning those which have never been used), and therefore less vigorous action by that stimulator of rusting, rust itself. This view is supported by Mallet's observation that the rates of rusting of used and of idle rails become more nearly equal as the time of exposure is increased.

Among explanations offered by previous writers for the lessened corrosion of rails in use are:

1. That vibration causes shedding of rust and so, in the presence of less of this stimulator of corrosion, rusting will be diminished.

2. That vibration breaks up areas of different potential that are naturally present on the surface of iron or steel.

3. That there is a voltaic action between bright or polished and dull or rough iron which, in some manner not explained, lessens the total corrosion of the rail.

4. That the rise in temperature produced by the passing of trains causes a more rapid evaporation of moisture from the used rails, and for this reason lessens corrosion.

This paper proves that an E. M. F. exists between the top and other portions of used rails acting in such a direction as to protect the rest of the rail: but it is manifestly impossible that a current generated by corrosion of one part of a bar of metal in a single solution shall, by its protective action on the other part, lessen the total corrosion.

The writer presents the view that the lessened corrosion of rails in use is due to a combination of two of the causes mentioned by previous writers, viz., voltaic action between strained and unstrained metal in the rail, which results in a slower formation of rust on the cathodic portions, and that thereby the normal accelerative action of rust is greatly diminished; and the complete removal of rust from the top of the rail, where it would otherwise form most rapidly and exert the greater accelerative effect on rusting.

Chemical Engineering Laboratories
University of Wisconsin.

---

# Acid vs. Basic Steel for Castings[1]

By EDWIN F. CONE, New York.

Consideration of this subject is practically confined to open-hearth steel. And it is not so much a question of the acid as a competitor of the basic as it is one of comparison. About 85 per cent of the steel going into steel castings in this country is made in the open-hearth furnace. In 1915 the open-hearth output was 84.9 per cent of the total; in 1914 it was 87.1 per cent. Castings from the converter and the crucible are regarded as acid steel while those made from the electric furnace are either acid or basic. But in the latter cases melting conditions are so different from those ruling in the open-hearth furnace that the steel can hardly be considered when discussing the open-hearth product.

### Uses of Acid and Basic Castings.

There has been recognized for a long time a distinct dividing line between acid and basic steel castings. Castings which, before being put to their final use, are necessarily machined all over, or to a large extent, are almost universally specified and made of acid open-hearth steel. All other castings, principally bolsters, draw-bars, knuckles, etc., are poured from basic steel. This is the recognized practice.

The principal reason for this is not that one is inherently stronger than the other, but because acid steel, properly made, is usually sounder and freer from defects. Hence it is less liable to reveal defects when machined and is therefore less subject to rejection.

It is unnecessary to deal minutely with the reasons for this before such a representative assemblage of foundrymen and steel foundrymen in particular. Briefly, this condition in basic steel is due to its inherent wildness after it has left the furnace. There is in fact only one distinct handicap which prevents basic steel from possessing a decided advantage over acid steel for casting purposes. When the basic steel has left the furnace and is covered with its slag in the ladle, a reaction at once starts between the steel and the slag consisting of a combination between the calcium

1 The reference giving the source of this paper has been mislaid, but will be inserted next month.

of the slag and the silicon of the steel, by which silicon leaves the metal and goes into the slag and phosphorus leaves the slag and goes into the metal. The result is that the latter part of the heat is high in phosphorus and low in silicon—often low enough to cause the metal to be porous when cast.

Naturally steel in which such a reaction is constantly going on cannot be as dense and solid as that made in the absence of such conditions. In acid steel of course, the conditions are largely the opposite. It is purely a melting and not a refining process, and if carefully carried out the steel is inevitably sounder. This is the main reason why it is specified for machined and jobbing castings in general.

In the steel foundry department of one of the largest steel plants in this country I was astonished to see a few years ago a 25-ton basic heat being poured for 45 minutes into small molds. It is hardly necessary to recount that towards the end of the heat the crop of "cauliflower" sink heads was a large one. It was then the custom in that plant to order from the open-hearth department, a 0.25 per cent carbon heat for castings, and the molding floor was sent any heat ready at the specified time, whether acid or basic. The losses were always large.

To overcome a low silicon content in the last stages of a basic heat it is customary often to start with a high initial silicon, perhaps 0.40 to 0.45 per cent, especially where considerable time must elapse in pouring the heat. But even then, a basic slag being more highly oxidized than an acid slag, the metal at the end of the operation is more highly charged with oxygen; tending to less sound steel. The average basic heat will analyze lower in silicon at the end than at the beginning of the pour, often by 50 per cent.

### Attempts to Overcome Slag Contamination.

Attempts to avoid this slag contamination of basic steel in the ladle have been many. Some have tried to remove the slag from the ladle and substitute an acid slag but without gratifying success, so far as I know. Only one really effectual means of avoiding slag contamination has been accomplished. This consists in tapping a heat through one ladle into another, leaving the slag in the first ladle. By tapping the metal from the furnace into a ladle containing a nozzle and stopper about 6 inches in diameter, and then bottom-pouring the metal into a second ladle, all the slag can be retained in the first ladle. Such a method is claimed to be entirely effectual in overcoming the slag contamination, but to carry it out the steel must of course be run excessively hot in order to undergo this transfer and still be suitable to avoid misruns. In addition the metal is not benefitted but rather injured by being made excessively hot. The furnaces also are injured more quickly and the fuel cost is higher, so that the cost of the furnace repairs and the additional ladle make the practice virtually prohibitive.

### The Addition of Ferro-Alloys.

It can hardly be gainsaid that the best steel is made entirely in the furnace and not in the ladle. This is recognized by most metallurgists. The acid process has a distinct advantage in that additions of ferro-manganese and ferro-silicon can be made without difficulty directly to the metal in the bath, whereas in the basic practice this is not the case. Though many acid foundries add the manganese to the metal as it flows into the ladle, careful investigations show that the steel is better if these additions are made to the furnace, even though the consumption of manganese is greater.

Because of the reactions between the basic slag and the metal in basic practice, these recarburizers must be added largely to the ladle. Some large producers of basic steel castings add a part of their silicon to the bath in the form of 11 per cent silicon pig and then obtain the desired silicon content in the steel by adding the 50 per cent alloy to the ladle. The ferro-manganese is added either to the bath after the high silicon pig or to the ladle after the 50 per cent alloy, or a part is added both ways, depending on conditions. The last is the more common practice. In any case, the functions of the silicon and the manganese as purifiers, scavengers and strengtheners of the steel are more thoroughly and efficiently performed by the intimate mixing and contact secured by finishing the steel in the furnace. You can't make as good a loaf of bread by introducing part of the ingredients after the kneading.

### The Question of Oxygen.

The question of oxygen is an important one in comparing these two grades of steel. To what extent oxygen in steel is harmful is not definitely decided. An authority stated recently that the results of extensive investigations warrant the conclusion that oxygen in steel, if it exceeds 0.01 per cent, tends to produce brittleness under shock. He gives the oxygen content of acid and basic open-hearth steels, as deduced from a large number of analyses as follows:

| | Per Cent. |
|---|---|
| Acid open-hearth steel ......... | 0.019 |
| Basic open-hearth steel ......... | 0.019[1] |

The difference here cited is not a large one, and it is just as easy to make a high oxygen acid heat as a poor basic heat if the furnace practice is not carefully watched.

Basic open-hearth steel, however, other things being equal, is of necessity the more highly oxidized one. The reactions and conditions involved cause this. In commercial steel castings this question is not likely an important one, as many basic castings are used successfully under conditions necessitating the withtanding of severe shocks. It is, however, a fact that more manganese is necessary as a neutralizer of this more highly oxidized condition than is the case in acid steel. The manganese consumption is therefore higher, as is also the silicon for reasons previously stated.

But in electric steel castings, even from a basic bottom, the manganese consumption is decidedly lower than with the acid or basic open-hearth. This shows the healthy condition of the steel, especially as to its oxygen content. From one-third to one-half as much manganese is necessary in electric practice as in the open-hearth to achieve the same results.

In normal times basic steel is considered less expensive to make because of cheaper pig iron and scrap. But these are more or less offset by the greater cost of the furnace lining and lime additions necessary. The result of the refining action of the basic furnace is a steel purer in respect to phosphorus and sulphur than is the acid steel. It is doubtful whether this alone is a particular advantage. The harmful effect of phosphorus and of sulphur in particular within limits has been exaggerated and it is not likely that this difference alone confers any special merit on basic steel. Electric steel can be made so low in these two elements as to be considered by some a disadvantage.

1 One of these figures must be wrong; a correction will be given next month.

Because selected materials must be used in making acid steel, many engineers have thought that a better grade of steel results. This is not a full statement of the case. It is the inherent conditions of the two processes that rule. Electric steel from the poorest scrap on a basic bottom can be made that is equal or superior to the finest crucible steel made from the most expensive selected stock.

### Comparative Physical Properties.

As to comparative physical properties, one of the largest makers of both acid and basic steel castings in the country gives it as his opinion that basic steel shows higher ductility for a given tensile strength than acid steel and as good an elastic ratio. I am unable to verify this statement from investigation. I have, however, seen some remarkable results from basic steel castings, superior to those from acid steel.

So many factors enter into this question that a very thorough investigation would be necessary to decide it, in my opinion. If basic is better, it is doubtless due to the fact that the refining conditions are an important factor. In the acid process old scrap is constantly remelted: the only virgin metal is the pig iron. In the basic, old scrap is refined in remelting and the proportion of pig iron or virgin metal is twice as great. These may be important factors.

### Basic Castings From Acid Scrap.

A very interesting modification of the usual basic process for producing steel castings is being practiced successfully by a large foundry in this country. The results obtained are interesting and striking. The only difference between the procedure at this foundry and at regular acid foundries is that they buy the same scrap that the acid producers use and a grade of pig iron similar in every way except its silicon content. The operation in other respects is the same as regular basic practice. Less time by 50 per cent is used or necessary. The additions are made as in usual basic practice. The time for refining and hence for completion of a heat is less, as well as the wear on the furnace.

While the probable expense of this practice per ton of metal in the ladle may perhaps be more than for acid metal, though the opposite is claimed by the interested parties, it is asserted that the metal is better than either acid or regular basic and that the percentage of rejected castings is less by a considerable margin.

In favor of this argument is the fact that the absence of considerable refining, with consequently less chemical action, tends to produce a less oxidized metal resulting in one low in phosphorus or sulphur or containing less inherent wildness. Castings made by this procedure are continually competing with the same castings from acid foundries; they are reported as unusually sound and free from cracks and other defects. Locomotive frames, ship castings and machinery parts have been on the market from this foundry for five or six years now and are reported by users or inspectors as of the highest grade. It is claimed that the theory that basic steel is not suitable for the castings commonly made in acid has been exploded. It is at least a fact that here is a case where miscellaneous jobbing castings of all sizes, from very small to large ones, are made in basic steel and with excellent commercial results.

### German and American Steel Castings.

It is interesting to compare the relative open-hearth steel casting output of this country and the casting output of Germany. The following table gives parallel figures of the percentage of acid steel castings in the total steel foundry output of the two countries for the last 15 years:

| | United States | | Germany | |
|---|---|---|---|---|
| Years. | Acid open-hearth castings per cent of t'l. | Total open-hearth castings, gross tons. | Acid castings per cent of t'l. | Total castings, metric tons. |
| 1901 | 68.4 | 301,622 | 37.0 | 107,210 |
| 1902 | 69.6 | 367,879 | 40.0 | 116,524 |
| 1903 | 66.3 | 400.348 | 34.3 | 131,756 |
| 1904 | 67.5 | 302,834 | 30.3 | 152,814 |
| 1905 | 60.9 | 526.540 | 35.1 | 186,131 |
| 1906 | 56.5 | 719,891 | 41.0 | 189,313 |
| 1907 | 50.9 | 746,525 | 40.4 | 211,498 |
| 1908 | 50.4 | 311,777 | 40.1 | 192,883 |
| 1909 | 49.0 | 601,040 | 40.3 | 206,456 |
| 1910 | 49.7 | 863,351 | 42.5 | 262,811 |
| 1911 | 53.3 | 571,191 | 37.9 | 269,372 |
| 1912 | 49.0 | 870,848 | 31.1 | 321,663 |
| 1913 | 49.4 | 910.216 | 30.1 | 362,916 |
| 1914 | 44.7 | 604,317 | 29.1 | 298,338 |
| 1915 | 54.7 | 735.332 | 27.8 | 694,515 |

In this country there has been a gradually decreasing proportion of acid castings since 1901, with the exception of the years 1911 and 1915. In Germany the basic predominates and is surprisingly larger than in the United States. This is especially true in the last two years under war conditions, though as a general rule Germany's use of basic castings is more extensive than ours. Since 1906 the falling off in the proportion of acid castings there has been quite pronounced.

Speculation as to the cause of this difference in conditions in the two countries is not likely to be profitable. We have often heard it said that German efficiency has produced better castings than American practice, be it acid or basic steel. It is probable that the general use to which they are put is not greatly different in the two countries. If this is so, the Germans must possess some method by which their basic castings are more acceptable than ours or else American foundrymen have too little faith in the metal they make. Is the desire in this country for tonnage rather than quality the answer? Or do the Germans produce a large proportion of their castings from acid scrap on a basic bottom?

### The Gain in Basic.

The gain of the basic on the acid castings has been pronounced in both countries. There is no reason why the basic should not continue to gain. With rapid advances in metallurgical practice it is not unlikely that a way will be found whereby basic may become equally interchangeable with acid steel castings. To what extent electric steel castings may affect this question is important. As bearing on this, it is interesting to note that of the total steel casting output of the United States in 1909, only 0.05 per cent was electric steel. In 1915, electric steel castings comprised 2.6 per cent of the total and the output has only begun to grow.

# Governor-General Launches Vessel from Canadian Vickers' Yard

His Excellency, the Governor-General of Canada, successfully launched the 7,200 d.w. ton cargo steamer "War Faith," at the yard of Canadian Vickers, Limited, on Saturday morning, in the presence of prominent shipping men, harbour authorities and the company's officials.

His Excellency, who was attended by Captain Clive, addressed the workmen after the launch.

The S.S. "War Faith" was successfully launched to go into service this year from Vickers' Yard, she was built under contract from the Imperial Munitions Board, under the supervision of Mr. James S. Bonnyman, acting on behalf of the British Ministry of Shipping.

This vessel has the following dimensions:—Carrying capacity about 7,200 deadweight tons; length, overall, 393 ft. 6 in.; breadth, 49 feet; depth, 30 feet.

### LAUNCH OF S.S. "WAR FAITH" AT CANADIAN VICKERS.

The s.s. "War Faith" was successfully launched on Saturday morning by His Excellency, the Governor-General of Canada, and immediately after the launch His Excellency addressed the employees. His Excellency said:—

"To-day you have had the opportunity of witnessing the launch of the ship named "War Faith," and which I venture to say is everything that could be desired in shipbuilding. That ship is, in a very few days, going to take her place in that great sea and become a ship of war and a unit of what is described as the Mercantile Marine. From the very beginning of the war we obtained control of the sea, and as long as we keep it, victory is bound to come to us.

We are all proud to read of the great victories which our allies are gaining on all fronts. As we read of these from day to day they must appeal to the imagination of the people that victory will come sooner or later by our highly organized powers. Success is now attending our efforts but we all know that before peace and final victory is won we must go on probably for long days of effort and sacrifice. We have the fullest belief in the military capacity and the splendid capacity of our men who are fighting on the different battle fronts, and it is for us who remain here in security to see that the effort of these men to do or die is not lost.

From the beginning of the war, and so until the end, one of the great problems we have to face will be shipping. On this side of the continent there are both men and material for all that is necessary for the prosecution of a great war, and the great problem will be to see that this continent, which I may say, has never yet had, during the course of its career, to put forward its best effort, to now do so.

We know that every man, woman and child is able to take their part. We all know that lost time means loss of lives, and it is for each of us to see that we make use of all our material resources to win the war.

We are proud of the record which Canada has made during this war, and I am sure that the work will be carried on week by week, month by month, until a successful conclusion is brought about.

Everyone can help to win this war; we are all efficient and equally accomplished in something or other. Our boys will have the satisfaction of knowing that you are doing your bit for the greatest of human causes of civilization. There are many difficulties, finance, etc., but after all, we know that no sacrifices have been made by us which, for one moment, can compare with what your brothers have done and are going through on the different battle fronts. Any sacrifice is worth making.

We have watched the launch of this new vessel today. I hope that all you men, whether in the office or in the workshops, will continue to pull together. Every plate closed, every rivet driven, every seam caulked, is doing your bit in winning the cause for which we are all fighting, and I trust that your combined efforts will be as successful for the ships now building, as they have been for what we have seen take the water today, and that you will renew your efforts."

His Excellency then called for three cheers for H.M. The King, and wished every success to the "War Faith."

Mr. Lynch, Managing Director of Canadian Vickers, asked the men to show their appreciation of the visit of His Excellency by giving three rousing cheers.

# Hamilton Notes

The Dominion Foundries and Steel Co. are widening their scrap yard crane runway to give a larger capacity. The yard was originally sixty feet wide. Quite an amount of space has been used up by cross tracks through the yard. The scrap is handled to the open hearth furnaces by means of an overhead track on the same level as the open hearth charging floor. Small buggies moved by hand, carrying the scrap charging boxes, are operated along this track onto a car running on a transverse track which delivers the buggy and boxes complete on to the open hearth charging track. With this layout very little room was left for scrap accommodation, so the company is changing from a sixty foot runway to a ninety foot one. The work has, of course, to be carried out during the regular operation of the plant which makes it somewhat of a difficult task. The Canadian Engineering and Contracting Company have the contract for the foundations, and the Hamilton Bridge Works Company the contract for the structural work.

One new oil tank has been completed for the Dominion Foundries & Steel, and one old tank moved to the new situation provided for them, at a distance from other buildings, as required by insurance companies.

The Frost Steel & Wire Company are erecting an addition to their plant on Sherman Ave., N., the new building is reinforced concrete and brick.

The Canadian Cartridge Co. are putting a second-story on one of their buildings to provide additional room to take care of the large orders recently received.

The Petrie Manufacturing Co., maker of the Magnet Cream Separator, is erecting a small concrete and brick addition.

The Steel Co. of Canada hope to have one unit of the new coke ovens ready for operation by November 15th. The Wilputte Coke Oven Co.. contractors for the ovens, are pushing the work with the utmost vigor. The new plant is a magnificent piece of work, and is a great credit to those in charge of it.

The new soaking pits and gas producers in connection with them, being erected for the Steel Co. of Canada by Alex Laughlin Co. are progressing favorably, and should be ready for operation before very long. These are being installed to help handle steel from the open hearths to the blooming mill.

Work has been commenced on a new office building for the Steel Company of Canada. The new building will accommodate the executive officials of the company. It will be situated immediately to the south of their present general office building at the Hamilton works. It is only a short time since this company put a third story on their present office building, but this is crowded out now, and a new building has become necessary.

The announcement of the marriage of Mr. H. S. Alexander to Miss Elsie Doolittle has been received by their many friends with a peculiar amount of satisfaction. Mr. Alexander has been for quite a number of years Assistant Treasurer of the Steel Company, and is one of the most respected and best liked members of the staff of that company. Miss Doolittle is a sister of Mr. C. M. Doolittle of the Dundas Stone Quarries. The wedding took place very quietly in the little Anglican Church at Mortimer Point, near Bala, Muskoka on September 15. Mr. and Mrs. Alexander left immediately for their honeymoon, which was to consist of a camping trip in the Nipigon District.

The Dominion Foundries and Steel Co., Ltd., are putting up a small addition to their plate mill.

The new service building for the Dominion Foundries and Steel Co., Ltd., is progressing rapidly, and it is hoped that it will soon be ready for occupation. The contractors, the Canadian Engineering and Contracting Co., general contractors for the building, have had trouble getting suitable labor, but the brick work is well advanced and quite a number of window frames have been set.

The Hamilton Bridge Works Co., Ltd., are making another small addition to their east-end plant.

The first meeting of the Hamilton Branch of the Engineering Institute of Canada was held in the Royal Connaught Hotel on the evening of September 21st. Mr. P. M. Lincoln, past president of the American Institute of Electrical Engineers, lectured in a most interesting manner on "The Development of Electric Power Transmission." Mr. Lincoln is connected with the Westinghouse Electric and Manufacturing Co. of Pittsburg. He is an engineer of international reputation and is an authority on the subject on which he spoke. The second meeting of this Branch of the Institute was held on September 30th.

Mr. Robert Hobson, President of the Steel Co. of Canada, has been appointed a member of the new National Railway Board. Mr. Hobson's training in former years in railway work and later his very broad experience in transportation problems connected with the immense concern of which he was for long general manager, peculiarly fit him for the new duties on the board. It is understood that Mr. Hobson is giving his services gratuitously, only receiving reimbursement of his expenses.

## NOTES FROM NEW GLASGOW, N.S.

It is reported that Mr. Frank H. Crockard, who recently resigned as President of the Nova Scotia Steel & Coal Company, Limited, may be summoned to Birmingham, Alabama, to build the contemplated $25,000,000 steel plant which the Woodward Iron Company is planning with the aid of the Federal Government to erect in that district.

The Woodward concern operates five blast furnaces with an annual capacity of 450,000 tons of pig iron. It, also, produces approximately 3,000 tons of coke daily from its 170 by-product coke oven plant. The coal and ore reserves are estimated at 380,000,000 tons of coal and 300,000,000 tons of ore. The capital of the company consists of $10,000,000 of common and $3,000,000 of 6 per cent preferred stock.

Mr. D. H. McDougall, successor of Mr. Crockard, as President and General Manager of "Scotia" assumed his new duties on the 20th August.

Mr. L. W. Adams, General Superintendent of the Nova Scotia Steel & Coal Company, Limited, has resigned and is leaving for Bethlehem, Pa., this week. His successor has not yet been appointed.

Mr. F. W. Gray, who recently resigned from the Dominion Iron & Steel Company, has joined the Head Office Staff of the Nova Scotia Steel & Coal Company.

Mr. T. J. Brown was, on the 21st August, appointed General Superintendent of the Nova Scotia Steel & Coal Company's plant at Sydney Mines, having charge of all operations of the company in that district. Mr. Thomas H. Hartigan is associated with Mr. Brown as assistant.

The various shell finishing concerns in this district have changed over to the manufacture of shrapnel shells. The change-over, naturally, entailed considerable changes of tooling and equipment, with a consequent slowing up in production; but by the end of the month, it is expected that all shops will be working to their maximum output.

The various foundries and machine shops of the district report business good, and booked with sufficient business for some months to come.

The Maritime Bridge Company is working to capacity and prospects of continued activity are good.

The "Scotia" Company reports a very good production for the current month and order books well filled. Practically the full output is for war material, direct or indirect.

The Eastern Car Company is making good progress on their various orders, and at present is working on their C. G. R. order.

The Canada Tool & Specialty Company are well booked with orders, chiefly for small tools and gauges for shell finishing plants.

# The Relations Between Engineering and Science[1]

HENRY M. HOWE.

We may well approach our subject of the relation between engineering and science by defining these two.

Engineering is the application to man's use of special knowledge of mechanics and of the properties of matter.

Natural science is the correlation of natural phenomena, often combined with their discovery. Emerson says:

"Science is nothing but the finding of analogy, identity in the most remote parts."

This finding of analogy is correlation. But though science has correlation for its essence it also includes discovery. Science thus has two aspects, it correlates the uncorrelated and hence empirically known phenomena and it discovers new phenomena and correlates them simultaneously. Their correlation is of origin, congenital. Or, if you will not go so far with me, let us agree that engineering is essentially application and science essentially correlation with or without discovery. In this view engineering is not a science but an art with a scientific basis. A man who is an engineer may correlate his own or others' discoveries, as he may walk a mile or pledge a health, but he does it not as an engineer but as simultaneously a natural philosopher.

From this point of view pure science in its relation to engineering seems to-day to be in an intermediate stage of its asymptotic evolution from the state of a follower to that of an absolute dictator. The first reason why this evolution has to follow this general course is that application must needs precede correlation.

Man like the other animals from the very first can survive only as he applies nature's laws to his needs, as he conforms to them, so that he begins applying them inconceivably earlier than he begins to formulate them or even to be capable of formulating them.

The second reason lies in the unfathomable complexity of the laws on which engineering must needs be based.

The engineering of the savage is military. His existence depends on his power to kill his enemies and incidentally his game by means of weapons made from the materials at hand. Of these materials he knows only certain prominent properties irrelated to each other and to the rest of nature. If this knowledge can be said to consist of laws they are only the most minute fragments when compared even with the fragments of laws which we have joined up. They are fragments comminuted to the second degree. The explanation of these fragments the savage has never sought. Yet the laws themselves were as complex when our forefathers were naked as they are to-day. The Bornean or Fiji knows that wood is strong, stone stronger, and iron stronger still, though corruptible by rust. Armed with this and all other knowledge which he has he destroys those who else would destroy him. The survival is not of those who formulate knowledge but of those who best apply it, and so there evolves a race which applies successfully the laws which it may never even think of thinking of.

By and by evolution lifts certain men so far up out of the imperative need of ceaseless viligance lest they be slain by their fellows or by nature as to give them the opportunity to consider their environment, and note the analogies between phenomena which at first seem irrelated. These are the first men of science. Before them the ratio of observed to correlated phenomena was that of a small body to zero, and hence was infinity. With them that ratio fell from infinity to finiteness, but it was still extremely small.

As the accumulation of observed phenomena goes on and with it the organization and elaboration of society certain men come to excel their fellows sufficiently in their mastery of this knowledge, and in their ingenuity in applying it, to become recognized as a special class, engineers. More slowly the accumulation of observed analogies becomes so great that those who master it become recognized in their turn as a class, the natural philosophers or men of science.

These philosophers address themselves at first to correlating phenomena, which, however familiar, are known as yet only empirically, and thus to explaining that which engineering has long known how to do, has known in part since the days of Assyria, of Homer, and of Kephren. But this is to trail after engineering, to explain its exploits as the minstrel glorifies those of the warrior. By and by science becomes able, through its accumulation of correlations, to point out to the engineer how he may better his service to man. But this is to snatch a share in the leadership, and add it to the continuing labor of correlation.

From this time on science increases continuously the share which it has in the direction of engineering. It is engaged ever more and more in discovering and simultaneously correlating new knowledge, and less and less in the gradually vanishing work of the correlation of the old empirical knowledge with which alone engineering formerly worked. With the completion of this latter task science might come to be the sole guide of engineering, but for two considerations.

First, as engineering adopts the knowledge which science has correlated it simultaneously unearths new uncorrelated knowledge. Science indeed correlates this in turn, but not instantaneously, so that engineering has always at its hand both that which science has correlated and its own empirical discoveries which science has not yet had time to arrange. As optimists we may well expect that this uncorrelated knowledge will form a gradually decreasing fraction of the whole, but can we expect it ever to vanish completely? Must not science's approach to exclusive leadership be asymptotic?

We begin to get a glimmering of the vastness of the

[1] Introductory address of the chairman of the Section of Engineering of the American Association for the Advancement of Science given at the meeting held by invitation of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, New York, December 29, 1916.—Reprinted from Science, N.S., Vol. XLV., No. 1160, Pages 273-275, March 23, 1917.

scheme of creation when we remember that every lengthening of man's artificial vision by means of telescope and camera, every new strengthening of telescope, sensitizing of plate, and lengthening of exposure brings a proportional increase in the number of visible suns, telling us that even at that inconceivable distance we have not begun to approach the limit of the discoverable universe. When we turn from telescope to microscope and thence to the inferred constitution of matter, we find with every new refinement of observation and inference a proportional addition of new wonders, a proportional increment in the complexity of natural phenomena. Hence while we may speculate that, as there must be a place where the stars end, so there must be a degree beyond which the subdivision of matter can not go, and a limit to the number of nature's laws, we may well ask whether either that limit or the limit of stellar space will be reached in that little throb in the pulse of the universe which we call the habitable period of this earth. Will man survive long enough to complete the discovery of all laws, so that no uncorrelated phenomena will remain for the engineer to unearth?

The second of the two considerations which tend to postpone the completion of science's leadership is that the beautiful as distinguished from the useful and the good will increase without limit its demands upon the work of the engineer. Though the beautiful itself should in time be capable of complete mathematical analysis, who shall say that that time, now seemingly so inconceivably remote, can arrive during man's earthly stay?

---

Is it not probable, when peace terms are dictated, that France will not only demand the restitution of Alsace and Lorraine, but also the annexation of sufficient German coal and coal fields to redress the mineral deficiencies of France. In 1913 France produced 40,000,000 tons of fuel while her consumption reached 60,000,000.

## DOMINION TRADES CONGRESS IN HAMILTON.

The Dominion Trades congress will hold its next session in Hamilton. By an overwhelming vote, 209 to 98, Hamilton was selected for the scene of the next gathering in preference to Winnipeg. Word to this effect was received recently from the industrial commissioner, C. W. Kirkpatrick, who was sent to Quebec to present the claims of Hamilton. The local delegates appreciated that there was a good chance of carrying the convention for Hamilton next time, but felt that with the industrial commissioner present to impress on the delegates the desirability of this city from a convention standpoint, they were bound to win.

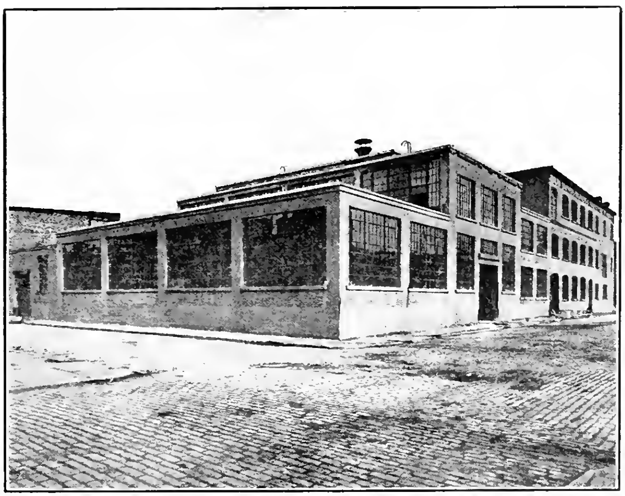
## INSTRUCTION IN METALLOGRAPHY.

At the beginning of the summer, a plan was under consideration for giving laboratory instruction in Metallography in the Metallurgical Department at McGill University during the winter months. A laboratory was specially arranged and microscopes obtained for this purpose, and instruction was to have been given by Mr. S. W. Werner, who has made a specialty of this subject.

Unfortunately, however, Mr. Werner has accepted a position elsewhere, and it seemed that the course would have to be abandoned; but eventually two gentlemen: Messrs. C. F. Pascoe and Mr. H. J. Roast have expressed their willingness to conduct a class in this subject. It has been aranged that the instruction will be given every Monday evening, beginning at eight o'clock; the first class being on Monday, November 4th. The course will consist of fifteen periods, and a fee of twenty dollars will be charged and will be payable in advance to the Bursar of the University. As the accommodation is limited, application for admission must be made in advance to Dr. Alfred Stansfield, McGill University.

---

When teeming vanadium steel there is a greasy or oily scum which floats on the surface if the metal has been properly made.



**New Foundry recently completed by Darling Bros., Ltd., Montreal.**

# W. W. BUTLER,

### Vice-President and Managing Director Canadian Car and Foundry Co.

If anyone believes in patronymics, then we must conclude that away back in the dim and distant past, an ancestor of W. W. Butler was a serving man in some Baronial castle in England. To-day Butler is in Canada serving the nation, not in the way the head of the family did centuries ago, but in a bigger and better manner. Perhaps Canada is synonymous with service and opportunity and that is why the Vice-President and Managing Director of the Canadian Car and Foundry Co., crossed the Border Line in the early days of the century and cast in his lot in this country in an endeavour to help solve our transportation equipment problem.

Wilson Workman Butler is an American by birth, but like so many other of Uncle Sam's men, found his real opportunity for service in Canada. He came here some seventeen years ago, and after sampling our life and work, decided that he could not do better than cast in his lot with us, so a half-dozen years ago took out naturalization papers, and to-day is a full-fledged Canadian citizen. Butler was born in Danville, Ohio, in 1862, and after a pretty thorough education in the Danville Select School, joined the John Shillito Company of Cincinnati. His real work was to come later when he joined the Sterlingworth Railway Supply Company, and from that concern went to the American Car and Foundry Company. When the present Canadian Car and Foundry Company emerged from the hands of that master-mergerer Max Aitken, and started on its career as the chief supplier of rolling stock for the Canadian roads, the officials looked abroad to find a man capable of holding down the job. They found that W. W. Butler was the best man in sight, and took him from the American Car and Foundry Company, and made him Vice-President and Managing Director of the Canadian Car and Foundry Company.

At the beginning of the century neither railroad building nor railroad car construction were big industries in Canada. We had not then begun to realize that Canada's century had come. The great era of railroad building and the marvellous expansion which took place in Canada during the early years of the century existed only in the vision of a few big men. It is only men who "saw beyond the skyline, where the strang roads go down," that "heard the tread of pioneers, of nations yet to be, the first low wash of waves, where yet shall roll a human sea." Just at this time Canada embarked on a great emigration policy. In thousands of towns and villages throughout the British Isles, on the continent of Europe, and in the United States, people were told of Canada's virgin soil; soil that only awaited the plow to become a source of wealth to the tiller. With this emigration policy started a great era of railroad building and of necessity railroad equipment building was pushed with a vigour that was unheard of a few years before.

It, of course, all works out as a mathematical problem, the carrying of these tens of thousands of newcomers to their homes on the prairies, the supplying them with machinery, clothing, household utilities, fuel and their thousand and one other requirements, and then to carry out their grain, cattle and other produce. The task required thousands of miles of railroad lines and tens of thousands of cars, locomotives and other railroad equipment. Thus in a very real sense car building became a national problem, and became associated with the country's growth and expansion. In this respect the peopling of the Canadian West forms a striking contrast to the settling of the Western States. In the latter case settlers from the crowded East streamed West across the Mississippi Valley and to the districts beyond in prairie schooners, a slow and cumbersome manner of reaching their destination. In contrast to that the Canadian settler was met at the boat or the Border Line, himself and his effects put into colonist cars, carried for thousands of miles over railroads and put down on his farm, the whole proceeding occupying days where the American settler took months.

Mr. Butler and those associated with him realized that they had a part to play in the settlement of the country. They reasoned that a country cannot be peopled unless people are carried in, people cannot be carried in without railroads, railroads cannot be operated without equipment, therefore car making is vitally associated with our emigration policy, with the growth and development of our country and the thousand and one problems connected with the opening up of a great undeveloped land.

The working head of the Canadian Car and Foundry Company is essentially a car builder and knows the manufacturing end from the ground up. In this respect he differs from some of his associates. It will be remembered that some time ago the Canadian Car and Foundry Company, like many other manufacturing concerns, launched out on a shell-making career. In the case of the Canadian Car and Foundry Company they tackled a huge Russian contract. Their shell experience turned out to be somewhat akin to the "three shell and pea game" of the country fair. Between that and the Bolsheviki, at the other end of the deal, the company's shell experience is not one for boasting; as a matter of fact it very nearly ended in disaster, and did bring about a demand for the removal of several of the directors. This demand did not include Mr. Butler. Both the old directors and the dissatisfied shareholders recognized him as a practical man and agreed that his services should be retained. As a matter of fact, he had little or nothing to do with the Russian shell game, and escaped the odium attached to that more or less unsatisfactory venture. Butler has a big job on his hands, but is a big man physically and mentally. He has sufficient knowledge of the country, of its transportation problems, resources and possibilities to enable him to size up the situation with amazing ability. He is a hard worker and neither spares himself nor those associated with him. In brief, he is a big man holding down a big job in a big way.

---

Political reasons have been assigned for the Germans repeated onslaught at Verdun but the true significance of these was that the St. Mihiel salient and Verdun are in the path to the Lorraine iron fields.

WILSON W. BUTLER,

Vice-President and Managing Director Canadian Car and Foundry Co.

M. J. BUTLER,
Managing Director Armstrong-Whitworth Company of Canada, Limited.

# M. J. BUTLER

**Managing-Director Armstrong-Whitworth Co.**

Mr. M. J. Butler sort of gives the lie to the popular theory that this is an age of specialists. On the contrary, his career shows conclusively that it pays to secure as broad and comprehensive a training as possible, and that the more one knows about many subjects and the wider his experience, the greater will be the final achievement.

Mr. Butler is a Canadian, born at Deseronto 62 years ago. He received his early education at the De La Salle Institute, Toronto; the University of Toronto, where he took a course in civil engineering; the Kent College of Law, Chicago, where he graduated as a lawyer and finally at St. Francois Xavier College, Antigonish, N.S. With this pretty thorough training in many subjects Mr. Butler launched out as land surveyor, practicising that profession and engineering for several years. Later came a period in railroad work, when he acted as building and water service engineer for the Santa Fe Road. Then a new field attracted him and he engaged in the wood pulp business for a dozen years. However, he could never get the railroad engineering bug out of his system, and in 1899 he gave up his wood pulp business and became chief engineer of the Bay of Quinte Railroad. Still later, he became engaged in other engineering work with M. J. Haney. In 1904, Mr. Butler was made assistant chief engineer of the National Trans-Continental Railway, and a short time afterwards was promoted Deputy Minister and Chief Engineer of the Department of Railways and Canals. From this post he shortly afterwards became Chairman of the Board of Management of the Canadian Government Railways. A year or two later he resigned to become Vice-President and General Manager of the Dominion Iron & Steel Co. Five years ago he severed his connection with them and became Managing Director of the Armstrong & Whitworth Co. of Canada.

What more comprehensive and varied training could a man receive than that undertaken by the subject of this sketch? An engineer and lawyer by professions, he became in turn surveyor, engineer, railroad operator, pulp wood dealer, a civil servant, head of a great iron and coal company, and finally found himself manager of a great English manufacturing establishment. In a very particular sense Mr. Butler shows the evidence of his wide experience and comprehensive training; he has known what it is to rough it in the wilds of the country and has been made familiar with the engineering, transportation and manufacturing problems of this country. His experience as a business man has kept him in the closest possible touch with the developed and undeveloped resources of the land. His training as a civil servant has given him an insight into the governmental end of big business.

While Mr. Butler was a civil servant at Ottawa he had an unique experience, but one which doubtless proved invaluable to him. Ever since Confederation the Intercolonial Railway had been a political football and a sort of haven for the office seeker and the patronage dispenser. The railroad had been built as a bribe to induce the Maritime provinces to enter Confederation, and one of the conditions laid down at that time was that the freight rates should be kept as low as possible. In addition to that, the road was recognized by both political parties as a vote getter. To hire or fire a charwoman around a way station almost meant a special order-in-council, while the discharge of a section hand was enough to bring on a general election. As a result of these handicaps the road was always mismanaged and always in debt. At times a new minister of railways would appear and with the courage born of high ideals and newness to his task would announce that he was going to "take the road out of politics" and cleanse the Augean stables. He never got very far with these high ideals before he ran foul of the party machine and got hopelessly entangled. Thereafter he was very apt to go along the line of least resistance; in other words, he did as all his predecessors had done, and never hired or fired an office boy or a track walker without first consulting the party bosses.

About the time Butler became a civil servant in Ottawa the Honorable George P. Graham, Minister of Railways and Canals, took the bull by the horns, or more properly speaking, the Intercolonial Railway, by its terminals, and shook it loose from its party affiliations and put it under a commission.

Butler was entrusted with the task of steering the ship of state as represented by the Intercolonial between Charybdis and Scylla. It is a safe bet that this job was no cinch, and if Michael J. got a few extra gray hairs during the process, it is not to be wondered at. However, he made a success of the undertaking, and at the same time performed his task so well that he landed another and more remunerative job. As head of the Intercolonial he had to chase up and down the line a great deal. Now no one can travel over the Intercolonial for very long without discovering that the Dominion Steel Corporation is an important factor in the Maritime Provinces. Evidently, Mr. Butler concluded that it was the "whole works" " 'Way Down East," and severed his connection with the Government to join the Dominion Iron & Coal Co. as Vice-President and General Manager, So it came about that instead of being a civil servant, M. J. Butler became boss of a big corporation where there were no special need to be "civil" and where he could swear a bit without having it made the subject of a parliamentary inquiry or being reprimanded by some officious fellow civil servant. However, it is pretty safe to say that while a civil servant, Mr. Butler made many friends for the Government.

In selecting Mr. Butler as their Canadian representative, Armstrong & Whitworth Co. showed a great deal of wisdom. They picked out a man who knows the country from end to end, a man who knows the "inside ropes" in so far as the Government was concerned, a man who by his education, training and character is competent to keep their interests to the fore.

---

Vanadium steel should not be melted with too thin a slag, otherwise the metal becomes oxidized. The alloy should not be required to cleanse the both of all impurities brought about by bad furnace practice.

# Non-Metallic Inclusions: Their Constitution and Occurrence in Steel

By ANDREW McCANCE, D.Sc., Assoc. R.S.M. (Glas.)

Annual Meeting of Iron and Steel Institute,
London, May 1918.

The important part which non-metallic inclusions play in causing failures and producing defects in all manner of steel products is not yet fully realised. Much defective steel is bad, solely because of the number of non-metallic particles which it contains, and fully 90 per cent of the failures due to faulty material which have come under the author's notice have been traceable to this cause alone.

### Inclusions are a Source of Weakness in Stressed Material.

When material has cracked under a stress which experience has shown it should have safely carried, it is advisable always to examine the crack along its whole length, and when this is done in many cases it will be found that the crack passes through groups of inclusions, while in cases where it can be traced to its origin it is not unusual to find that it has started from a segregation of non-metallic particles.

A piece of steel was heat treated in such a manner as to produce slight intercrystalline brittleness, and it was then stressed above its elastic limit. Numerous small cracks appeared, and in nearly every case they started from one or more non-metallic inclusions. Plate I., Photo No. 1, shows one of such cracks, and in each place where the crack had its maximum width there were inclusions. Some of these were very minute, and in the left-hand bottom corner there was a group of five, none of whose diameters exceeded 1-500th of a centimetre. With large inclusions, especially after rolling operations, even the best material is weakened. A heavy slab known to contain inclusions was heat treated, and tensile tests taken along the length in the direction of rolling, and at right angles to this direction through the thickness of the slab. The length test was in the same plane as the centre portion of the thickness test, so as to make them in every way comparable, and in breaking the tests the elastic limit was taken by an extensometer. The results gave:

| | Elastic Limit. Tons. | Ultimate. Tons. | Elongation in 2 Inches. P.c. | Contraction. P.c. |
|---|---|---|---|---|
| Length test A. . . . . . . . . . | 24 | 43.2 | 27.0 | 65.8 |
| Thickness test B. . . . . . . . . | 18 | 34.5 | 4.0 | 16.8 |

This difference is due solely to the presence of inclusions, which can be seen in the fracture tensile surfaces of Test B (Plate I., No. 2), in which they appear as thin circular discs due to the rolling operation.

In the first place, they have acted simply as small areas of no strength which have lowered the effective area of the test-piece, though this does not completely indicate their action. If a plate containing a hole is under tension the stress is not uniformly distributed, but is greater than the average at the edge of the hole. If the hole is an ellipse with diameters a and b, the distribution of the stress round the edge depends in what manner the hole is situated relative to the applied stress, but it has been shown that if one of its axes lies along the direction of stress the maximum intensity occurs at the edges of the axis at right angles to this.[1] In Fig. 1 the two positions are shown, and

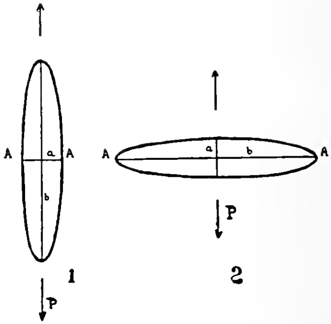



Fig. 1.

the maximum stress occurs in each case at A, and if the average tension is P, then

$$\text{Stress at A} = \text{P}\left(1 + \frac{2a}{b}\right)$$

For purposes of comparison, if we assume that a crack in a piece of steel was elliptical in shape and its

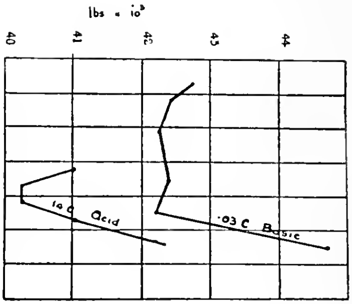



Fig. 2.—Strength of Acid and Basic Steel containing Manganese.

length was twenty times its diameter, then in position 1, Fig. 1,

---

[1] Inglis, Proceedings of the Institution of Naval Architects, 1910.

$$P_{max.} = P\,(1 + 2\cdot\tfrac{1}{20}) = 1\cdot1\ P.$$

so that, so long as it was pulled along its length there would be no great difference. But if it were pulled across this, as in position 2, Fig. 1,

$$P_{max.} = P\,(1 + 2\cdot\tfrac{20}{1}) = 41\ P,$$

and the stress at the ends would now be 41 times greater. It can at once be understood how dangerous cracks are when pulled at right angles to their length, and why they extend and grow longer. And this is the most favorable case, because the ends of cracks are not rounded, as we have assumed, but are sharp, which entails a still greater difference.

A circle is a special case of the ellipse, where a=b, and the stress at the edge of a circular hole is three times the average. This has been proved experimentally by two totally different methods,[1] thus confirming the theory.

If instead of holes we are dealing with inclusions whose elastic properties are quite different from those of the surrounding steel, the differences in stress at the edges will not be so great as for holes, but we can certainly say that the edge stress will be greater than the average, and it is sufficient for our purpose to know that such is the case. In steel, therefore, which possesses even slight brittleness the presence of inclusions may give rise to cracks when such material is stressed, though in steel which has received proper thermal treatment during rolling, forging, etc., in-

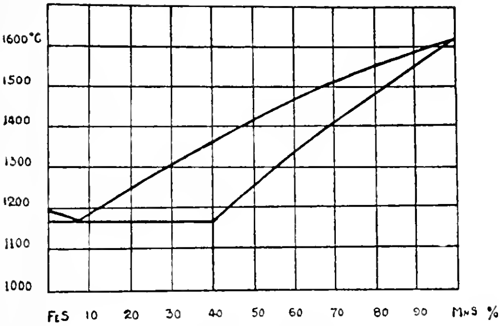



Fig. 3.—MnS–FeS Diagram.

clusions, so long as they are evenly distributed and small, will have an effect which is quite negligible. It is only when they begin to form groups that they have a detrimental effect, and this power which they have to segregate is, unfortunately, without control in the existing state of our knowledge, so that the only way to minimise the chance of segregation is to lessen the number of inclusions present.

Every mass of steel contains inclusions to a greater or lesser extent, since it is impossible to manufacture steel without them, and the object of this paper is to consider what is the composition of the non-metallic material which gives rise to inclusions and how it is formed, so that the conditions which favour its production and retention by the steel may be avoided.

**The Position of Inclusions in Relation to the Ingot.**

The idea that non-metallic inclusions were soluble in steel has been put forward by Ziegler, but there is no evidence to support this contention. Giolitti and Tavanti[1] have specially examined the size of inclusions in steel quenched from the liquid state, and repeated the measurements on the same inclusions after annealing, and they cannot find any difference. The method is open to the objection that any soluble matter need not be precipitated on the material already out of solution, but may be deposited quite independently. But quite apart, the author is not aware of any facts connected with the manufacture which would support the suggestion of solubility in steel, and their practical importance is concerned with their existence as suspensions.

As a consequence they do not obey the laws which govern the segregation of other elements soluble in liquid steel; their ultimate position in the ingot is determined by secondary influences, or the laws of chance, and during the solidification of the metal they may be carried into any part by local movements and convection currents. The idea is commonly met with that the presence of non-metallic inclusions indicates a piped part of the ingot, but this is far from the truth. A piped part is often segregated, but the converse does not hold, and some of the worst segregations which the author has examined have come from the material between the centre and the outside skin. Increasing the amount of top and bottom cropping therefore, to get rid of inclusions, is a remedy based on ignorance. It may help at this stage to form clear views if some hypothetical cases are considered as near to practical facts as the limited data available will allow.

Being lighter than the steel non-metallic matter tends to rise to the surface, and it is of interest to examine this tendency a little closer. If we assume that such matter exists as spherical globules with a density of 4 (density of MnS, 3.99; $2MnO,SiO_2$, 4.0 to 4.12; $2FeO,SiO_2$, 4.0 to 4.14), and that liquid steel is no more viscous than mercury (a statement not far from the truth), some particles would rise if undisturbed at rates which would depend on their size, and would approximate to the following values:

| Diameter of Particles. | Velocity of Rising. |
|---|---|
| 10.0 x 10-3 cms. | 80.0 cms. per min. |
| 1.0 " " | 0.8 " " |
| 0.1 " " | 0.008 " " |

It can be said with moderate certainty that particles of 1/1000 centimetre diameter have practically no chance of reaching the surface, and as the diameter increases a larger proportion of each class will escape. For the purpose of illustration suppose an ingot of length 140 centimetres set in twenty minutes from the time the mould was filled, then during that time, if convection currents are neglected, the percentage of the number of particles of each size which would be entrapped in the solid metal would be as follows:

| Diameter of Particles. | Per Cent. Entrapped. |
|---|---|
| All over 3.0 x 10-3 cms | 0 |
| " 2.0 " " | 54 |
| " 1.0 " " | 88 |
| All under 0.5 " " | 100 |

This is given merely as an interesting method of show-

[1] Coker, Journal of the West of Scotland Iron and Steel Institute, 1913, p. 96. Preuss, Stahl und Eisen, 32, p. 2094.

[1] Annali di Chemeto Applicata, vol. ii, p. 260.

ing how rapidly the chance of being entrapped increases as the size of the particle gets smaller. This tendency will be greatly increased by the presence of convection currents which must play an important, though uncontrollable, part in determining the position and size of the inclusions in every steel ingot.

The question of the viscosity of liquid steel is of great importance from a practical standpoint. The teemer desires what he calls a "good fluid steel," since it is associated from experience with steel of good quality, and it can be seen that there is theoretical justification for this view. Temperature, therefore, plays an important role in increasing fluidity, or in other words, in lessening viscosity. This can be illustrated in a similar manner by a hypothetical case, assuming as before that the viscosity of steel closely follows that of mercury. The percentage number of particles $2.0 \cdot 10^{-3}$ cms. in diameter entrapped in the above mould would be as follows, other conditions being the same:

| Temperature above Melting Point. | Per Cent. Entrapped |
|---|---|
| 0 deg. C. | 65 |
| 60 " | 54 |
| 140 " | 41 |

In addition the time of setting, which increases with a higher temperature, would influence these results, and it can be seen that the disparity between the above figures would be increased still further by the temperature conditions of the liquid steel. To avoid inclusis, as high above the temperature of solidifying as practicable. We shall later see that practical results agree with this view.

The practical influence of time in decreasing the number of inclusions through the escape of the larger particles may be seen from the following analyses taken from a mixer,[1] the loss of manganese being due to oxidation:

| | | | | | |
|---|---|---|---|---|---|
| On tapping | Mn | 1.00 | After standing 1 hour | Mn | 0.80 |
| " | S | 0.07 | " " | S | 0.038 |
| " | Mn | 1.20 | " " | Mn | 1.00 |
| " | S | 0.06 | " " | S | 0.03 |

Time alone, however, from what has been said above, can never get rid entirely of inclusions, and from these figures it appears that 50 per cent of the particles of manganese sulphide were of such a size that they would remain suspended indefinitely.

Such particles in suspension have always a tendency to coalesce into larger particles, their power to do so being largely determined by their surface tension, and since they are suspensions, in a solidifying mass of metal they will always be found in the last portion of metal to solidify. While the last portions between the crystals are solidifying, the inclusions will be crowded together with every chance of coalescing into larger masses. The average size of the particles in the solid steel will consequently be larger than that of the particles which existed in the liquid steel.

Another deduction from this action explains why the inclusions in small ingots are generally smaller in size than the inclusions of large ingots, since the size will depend (other conditions remaining the same) on the volume enclosed between neighbouring crystal centres, for all the inclusions contained in this volume have the opportunity of coalescing as the last portion solidifies. The size of the inclusion has a direct connection with the crystal size of the solidified metal.

Just where the inclusion has segregated also contains the concentrated impurities held in solution, of which the most important as a source of defective material is phosphorus, so that the inclusions are surrounded by an envelope of material high in phosphorus (Plate I., No. 3). The material next the inclusion is, in fact, in a worse condition than the average to withstand the higher stress, which the presence of the inclusion entails in stressed material, and the inherent weakness is intensified. "Ghosts" in steel are nearly always accompanied by inclusions for similar reasons.

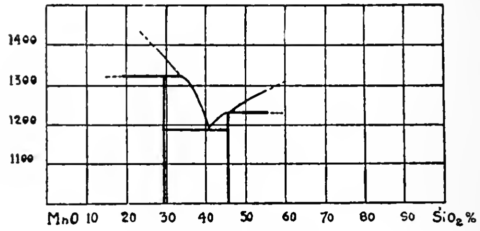



Fig. 4.—$MnO$-$SiO_2$ Diagram.

## Etching Reagents.

Our knowledge of special etching reagents for different classes of inclusions is very limited. Whiteley[1] recommends a solution for detecting sulphides made up of 5 grammes of gelatine soaked in 20 cubic centimetres of water for one hour to which 15 cubic centimetres of glycerine have been added, and the mixture heated until clear. To this is added 0.05 gramme tartar emetic dissolved in 1 cubic centimetre of water, and after filtering, 1 cubic centimetre of dilute sulphuric acid. To apply the mixture it is melted in warm water and a drop placed on the specimen while a cover-glass is pressed on top. Yellowish rings begin to form round the particles which contain sulphide. The author has found it advantageous to replace the tartar emetic by 0.1 gramme of silver nitrate. This forms a black stain which does not spread so much as the antimony sulphide. Another satisfactory method used by Comstock[2] is to etch with boiling sodium picrate as used for blackening the cementite, since $MnS$ is also blackened while silicates and oxides are left unaffected.

To distinguish between the latter the author uses a solution comprised of

| | | |
|---|---|---|
| A reagent. | Hydrofluoric acid (conc.) | 2 cubic centimetres |
| | Absolute alcohol | 98 " " |

For steels about three seconds etching is sufficient to darken sulphides and silicates, while oxides are left unattacked. For slags and scales a stronger solution is necessary, such as

| | | |
|---|---|---|
| B reagent. | Hydrofluoric acid | 8 cubic centimetres |
| | Water | 42 " " |
| | Alcohol | 50 " " |

[1] Houghton, Staffordshire Iron and Steel Institute, 1906.

[1] Journal of the West of Scotland Iron and Steel Institute, 1917, p. 79.

[2] Bulletin of the American Institute of Mining Engineers, 1916, p. 2103.

The time of etching with this solution varies with the class of material which is being attacked, and can only be determined by experiment. By the use of these reagents any inclusion can be classified as a sulphide, silicate, or oxide.

Hydrofluoric acid has a very peculiar ability to clean sections which have become rusted, and where the rusting is only incipient, a few seconds etching removes all traces of rust and leaves the section quite bright. It also can be used as a substitute for Stead's reagent to show up phosphorus segregation, especially in cast samples. In basic steels its action is often irregular, or seemingly so, for it attacks patches and develops a needle-like structure in them, especially in the neighbourhood of inclusions, though in acid steels this effect has not been noticed to the same extent.

To study the effect of different etching agents on inclusions the following method has been found of great use. A mild steel bar about 3 inches in diameter, had a hole drilled down its centre 5 inches long and $\frac{1}{4}$ inch in diameter, and a quantity of the pure inclusion which had been artificially prepared for examination was introduced into the hole and rammed down tightly, the hole being plugged by a well-fitting rod. This was then taken and forged down to 1 inch square from a temperature of about 1300 deg. C. in order to make the inclusion as soft as possible. Sections were taken from the part where the inclusion was located and polished, so that the effect of different etching agents could be conveniently studied. There is still room for considerable research in determining more suitable etching reagents which will reveal the constitution of inclusions in steel.

### Manganese Sulphide.

The beneficial effect of manganese on steel has long been known, and that it was highly valued was evidenced by the strenuous litigation which took place over the validity of the patent of Heath,[1] who was first to apply it to the manufacture of crucible steel for converting inferior grades of blister steel into grades of excellent quality. Thus very early in his career as a manufacturer of steel Bessemer had made additions of manganese part of his regular practice, and it was due to his instigation that the manufacture of ferromanganese was started in Glasgow in 1868. The connection between the presence of sulphur and the necessity for manganese additions was not long in being discovered, so that in 1876 it had been stated by Hackney[2] that to make steels forgeable the amount of manganese required was from three to five times the amount of sulphur.

The interest in this question seems to have died out with its successful solution in practical work, and it was not until microscopical work was developed that it again received attention. Microscopic examination of failures of steel parts led to the cause being ascribed to the presence of iron sulphide or sulphur inclusions, and Andrews,[3] one of the first workers in this field, recognised that these sulphur inclusions were "generally of the ovoid dove-colored type when manganese was present in excess." This surmise was shown to be correct by Arnold,[4] who was the first to show how the dangerous iron sulphide inclusion was replaced by dove-colored globules when sufficient manganese was present. He was able to confirm this later[5] when the remarkable results obtained by Brinell were published[6] with a steel of the following composition:

| Carbon. | Sulphur. | Manganese. |
|---|---|---|
| 0.46 | 0.56 | 1.06 |

which rolled well and showed no trace of red-shortness. It has been universally accepted since that the dove-colored areas were composed of manganese sulphide, and that the location of iron sulphide in between the grains accounted for the red-shortness of steels containing no manganese.

Theoretically 1 part of sulphur in steel requires 1.73 parts of manganese to form MnS, but practically more has been found necessary. Hackney stated[7] that a steel with 0.04 sulphur required 0.20 manganese, while a steel with 0.20 sulphur required 0.60 manganese—that was a ratio of 5 to 3.

Thomson[8] gave a ratio of 4 when the sulphur was 0.05 per cent, while Stead [9] stated that it was safer to have at least eight times the sulphur up to 0.06 per cent, and this figure is at the present time generally adopted in works practice. Brinell's steel, however, with 0.56 sulphur, showed no trace of red-shortness, although the ratio of manganese to sulphur was only 1.89, which is very close to the theoretical required. The deduction to be drawn from these figures is that as the percentage of sulphur gets less the ratio of manganese to sulphur must be increased if the bad effect of the sulphur is to be effectively remove. It has been concluded as a result that the reaction between the manganese and the sulphur in steel is therefore a balanced one, though strict proof has been wanting.

Schutz,[10] on heating a mixture of manganese and FeS in molecular proportions to 1495 deg. C. in a graphite crucible, got a slag and a metal button which analysed:

| | Slag. | Metal Button. |
|---|---|---|
| Iron | 11.49 | 93.79 |
| Manganese | 54.42 | 5.11 |
| Sulphur | 32.30 | 0.12 |

Starting with a mixture of iron and manganese sulphide heated to 1355 deg. C. the resulting products analysed:

| | Slag | Metal Button. |
|---|---|---|
| Iron | 3.48 | 84.47 |
| Manganese | 60.07 | 9.69 |
| Sulphur | 34.34 | trace |

These results were thought to show that the reaction was a balanced reaction, the analyses giving the approximate composition of the phases in equilibrium. Considering the melting point of MnS, however, it is extremely unlikely that his mixtures were in a suffi-

[1] "Manufacture of Iron and Steel," No. 8021, 1839. Those interested in this question will find most of the information in Bessemer's Autobiography, 1905: "The Case of Josiah Marshall Heath," F. Webster, 1856; Percy "The Metallurgy of Iron and Steel," p. 840.

[2] "Journal of the Iron and Steel Institute, 1876, p. 63.

[3] "Microscopic Examination of Flaws inducing Fracture in Steel," 1896, p. 20.

[4] Metallographist, 1900.

[5] Arnold and Waterhouse, Journal of the Iron and Steel Institute, 1903, No. I, p. 136.

[6] Ibid., 1901, No. 11., p. 254.

[7] Loc. cit.

[8] Iron Age, vol. lvii, p. 810.

[9] Journal of the Iron and Steel Institute, 1903, No. I, p. 146.

[10] Metallurgie, vol. iv, p. 659.

ciently fluid state to allow the reactants to separate completely from one another. The author has repeated the first of the above experiments, and found that the resulting products were by no means homogeneous, but the MnS contained metallic particles, when viewed under the microscope, which had not been able to separate themselves from the pasty mass. Schutz's results are on this account open to doubt, and they are the only experimental endeavour to show the balanced nature of the manganese sulphur reaction in steel.

On the other hand, Brinell's steel with 0.56 per cent sulphur and 1.06 per cent manganese indicates that the reaction in this case is complete, although very nearly the correct proportion of manganese is present. Hilgenstock,[11] repeating an experiment of Stead's[12] poured 400 grammes of molten 80 per cent ferromanganese into 440 grammes of molten FeS, and the resulting metal button weighed 406 grammes, and contained 9.04 per cent manganese and a trace of sulphur. The slag on top analysed:

| | Hilgenstock. | McCance. |
|---|---|---|
| Mns | 85.75 | 84.1 |
| MnO | 9.11 | 6.1 |
| FeO | 4.74 | 3.2 |
| $SiO_2$ | 0.70 insol. | 5.5 |
| | 100.30 | 98.9 |

This experiment of Stead's has been confirmed by the author, and it disproves conclusively that the reaction of manganese and iron sulphide is a balanced one, since the iron sulphide is completely reduced and the sulphur wholly transferred from a state of combination with iron to the manganese. What, then, is the explanation of the practicable fact that an excess of manganese is required over the amount necessary to form MnS, in commercial steels?

An interesting side light is thrown on this by the extensive investigation by Campbell[13] into the effect of manganese on the tensile strength of acid and basic steels (Fig. 2). Manganese has no effect on low carbon steels until the amount present is greater than 0.34 per cent, while in acid steels it even seems to soften below this proportion. When more than 0.4 per cent is present the tensile strength is increased and measurements of the electric resistance[14] prove that it is going into solution in the ferrite. The only inference that can be drawn is, therefore, that in open-hearth steels the manganese below 0.3 per cent does not go into solution in the steel, but is present in some form which does not affect the tensile strength. The manganese which is added to remove the sulphur must be divided and a part removed by some other element, so that only a portion goes to satisfy the sulphur. It is the necessity for this excess which gives to the action of manganese on sulphur in steel the appearance of a balanced reaction.

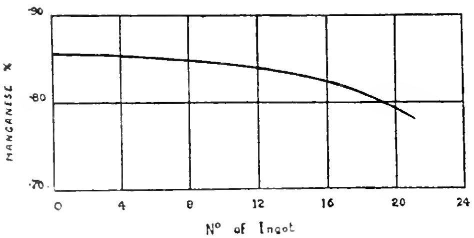



Fig. 5.—Variation of Manganese Content during Teeming. (Morgans and Roge

## The Reason for the Effect of Manganese on Steel.

Considerable discussion has taken place over the melting point of MnS, as it was thought to have great bearing on the explanation of the beneficial effect of manganese on steels containing sulphur, the contention being that if it solidified at a higher temperature than steel did, it would act as a solid nucleus for the steel grains to form round instead of forming a brittle cement in between the grains like ferrous sulphide. This view was put forward by Le Chatelier,[15] and the evidence of Baykoff[16] seemed to show that in certain crystals from blowhole cavities examined by him the centre part of the crystal was occupied by an inclusion of MnS round which the steel had solidified. The most careful and reliable determinations of the melting point of MnS by Rohl [17] gave a temperature of 1620 deg. C., so that such cases as those of Baykoff are possible, but in commercial steels MnS inclusions along with others are always found in the last portions to solidify. The presence of small quantities of MnO have a very marked effect on the melting point of MnS, and it is to this fact that the very varying figures given for the temperature of fusion of MnS may have been due. Manganese sulphide containing about 9 per cent of MnO can be quite easily fused with a temperature which does not exceed 1400 deg. C.

The more correct explanation of the prevention of sulphur red shortness by manganese is based on the fact that FeS is soluble in liquid steel, and separates out as an easily fusible eutectic between the grains when the steel solidifies. MnS, on the other hand, is insoluble, and the addition of manganese precipitates the sulphur from its state of solution in liquid steel.

## Is Ferrous Sulphide Present in Commercial Steels?

The author has never met any free FeS in commercial steels, nor on the views given above is it likely that any exists so long as sufficient manganese is present. There is the view, however, put forward by Rohl[18] that the FeS is not wholly reduced, but that a compound is formed having the composition 3FeS, MnS, which is capable of forming homogeneous solutions with pure MnS, the varying colours of inclusions being explained by a variation in the proportion of each present. When the evidence for this is examined no real support for it can be found. Rohl's diagram for the system FeS-MnS is reproduced in Fig. 3, and the thermal and microscopical data gave no evidence of the formation of a compound at A, but only indicate that this point is the limit of solid solution of MnS in FeS. The system is a simple eutectiferous one. Since the reaction FeS + Mn = MnS + Fe is not a balanced one, it is most unlikely

[11] Das Schwefel in Eisen. Erlangen, 1893.

[12] Journal of the Iron and Steel Institute, 1891, No. 11, p. 86.

[13] "Manufacture and Properties of Iron and Steel." p. 375.

[14] Lang, Metallurgie, 1911, p. 15.

[15] Bulletin de la Societe d'Encouragement, 1902, p. 368.

[16] Baykoff, Metallurgie, vol. vi. p. 3.

[17] Iron and Steel Institute: Carnegie Scholarship Memoirs, 1912, vol. iv. p. 28,

that the FeS is not completely reduced; but even assuming that solid solutions of FeS and MnS could exist in steels in the cold state, on heating such steels above 980 deg. C.—the eutectic temperature of Fe — FeS—the FeS would redissolve and diffuse into the surrounding steel, and on cooling again below this temperature it would not be redeposited in its original position, but would be deposited in between the crystal grains according to its habit and assume a separate micrographical existence. No better proof of this can be given than by referring to the work of Arnold,[19] where his micrographs Nos. 2 and 3 show the presence of FeS and MnS in the one section, although according to Rohl with such compositions only solid solutions of FeS and MnS should have existed.

Artificial inclusions of the two sulphides in steel have been shown by Steinberg[20] to grow smaller when quenched from high temperatures from a similar cause.

Sulphide inclusions in steels therefore may be MnS, but they are not likely to contain any FeS even in a state of solid solution.

### The Influence of Aluminium on Sulphides.

From the steel point of view the influence of aluminium on manganese sulphide inclusions was noticed by Arnold and Waterhouse.[21] When aluminium was present in the ingot the MnS collected into areas with a fan-like arrangement, instead of the normal isolated spots when aluminium was absent.

A piece of steel came into the author's possession which showed no trace of brittleness, with the composition

| Silicon. | Manganese. | Aluminium. |
|---|---|---|
| 0.055 | 0.066 | 0.057 |

—the manganese present is only sufficient for 69 per cent of the sulphur. This suggested that possibly aluminium could replace manganese by combining with the sulphur.

The heat of formation of $Al_2S_3$ is 126 calories, and is the highest heat of formation of the common sulphides, being considerably higher than that of FeS (24.0) or MnS (45.6). Hilgenstock[22] found that if just melted FeS was poured into just melted aluminium a reaction took place so vigorously that the resulting products were completely melted. His results gave a metal button and a slag which analysed:

| Metal Button. | | Slag. | |
|---|---|---|---|
| Al | 4·88 | $Al_2S_3$ | 60·46 |
| S | 0·36 | $Al_2O_3$ | 17·51 |
| Remainder iron | | FeO | 17·44 |
| | | $SiO_2$ | 4·80 |

As it is unlikely that FeO could exist in the presence of molten aluminium, the slag was probably made up of

| | | |
|---|---|---|
| FeS | 21·32 | forming compound $FeS,Al_2S_3$. |
| $Al_2S_3$ | 38·64 | |
| $Al_2O_3$ | 26·00 | |
| $SiO_2$ | 4·80 | |

Houdard,[23] heating aluminium in the presence of $H_2S$ with FeS and MnS, formed double compounds of the types $FeS,Al_2S_3$ and $MnS,Al_2S_3$, and Ditz[24] found that a thermit reaction could be obtained with iron sulphide or pyrites with the formation of a double sulphide such as a slag.

The author added a quantity of molten aluminium at about 850 deg. C. to an equal weight of molten FeS about 1250 deg. C. A very rapid reaction took place, and the slag which formed had the composition:

| | Per Cent. |
|---|---|
| $Al_2S_3$ | 77·65 |
| FeS | 0·88 |
| $Al_2O_3$ | 13·40 |
| $SiO_2$ | 0·20 |

The end product in this case only contains a small quantity of iron sulphide, and the reduction has been complete. The presence of $Al^2O_3$ is of course, due to the oxidation of sulphide, which is very easily reduced —even moist air converts it to alumina with the liberation of sulphuretted hydrogen. The difference between these results and the results of Hilgenstock and Ditz must be due to the difference in the ratios of aluminium to FeS. The latter used 400 grammes of FeS and only 70 grammes of aluminium, and the reaction was incomplete, while the author used equal weights and so obtained complete reduction.

Though the author has been unable to melt manganese sulphide and aluminium together, owing to the difficulty of preventing the MnS from oxidising, the great difference in their heats of formation and the experiments of Houdard makes it probable that aluminium will reduce MnS, at least partially if not completely.

The above results would explain why aluminium can replace manganese in removing the effect of sulphur in steel, a fact known for some time.[25]

An artificial inclusion of aluminium sulphide prepared as above was made, and is shown in Plate I., No. 4. This inclusion is peculiar. Of a very pale grey colour, the sulphide is entirely made up of small isolated spots, and practically no trace can be found of the original hole, as it has welded up and the sulphide has diffused into the surrounding steel. In appearance it is very similar to inclusions of $Al_2O_3$, described by Comstock.[26] A great many of the spots are really holes in which traces of non-metallic matter can be recognised only at the highest magnifications, owing to the action of water on the sulphide during polishing. The breaking up into small globules seems to be a peculiarity of aluminium inclusions, and the influence of aluminium on the structure of manganese sulphide observed by Arnold and Waterhouse being of the same nature can be ascribed to the partial reduction of the sulphide by the aluminium.

### Oxidation Products of Managanese Sulphide.

Manganese sulphide is very readily oxidised at high temperatures, and the oxidation products are of more

[18] Loc. cit.

[19] Journal of the Iron and Steel Institute, 1914, No. I. p. 400, Table III.

[20] Abstract, ibid., 1915, No. I. p. 618.

[21] Loc. cit.

[22] Loc. cit.

[23] Comptes Rendus, 1907, pp. 801, 1114.

[24] Metallurgie, 1907, p. 786.

[25] Reference may be made to castings made at Newburn Steelworks in 1890 which were "sound and tough" and gave good mechanical tests with the analysis: Carbon, 0.15; silicon, 0.84; manganese, trace; sulphur, 0.013; phosphorus, 0.038; aluminium, 0.19.

frequent occurrence, and have an even greater importance than the sulphide in causing defects in steel.

The introduction of the mixer by Massenez first drew attention to the importance of manganese sulphide, for in such furnaces as were first used it rose to the surface of the liquid metal as a pasty scum. There it was oxidised by the air forming MnO, and gave rise at the same time to the characteristic smell of $SO^2$. Such mixer slags were complex, and compositions given by Massenez[27] and Stead[28] were:

| | 1. | 2. |
|---|---|---|
| MnS | 28·01 | 15·65 |
| MnO | 20·23 | 30·40 |
| FeO | 25·46 | 7·45 |
| $SiO_2$ | 18·90 | 32·30 |
| $Al_2O_3$ | 5·00 | ... |
| CaO | 3·53 | ... |
| MgO | 0·43 | ... |

The FeO was produced by the oxidation of the iron, and it was soon found necessary to use basic linings to prevent the cutting away of the banks of the furnace. The silicon in such cases came from the pig iron, and Richards[29] stated that the average analysis from a large number of casts showed a distinct loss in the silicon content:

| | Per Cent. Silicon. |
|---|---|
| Average from blast furnace | 1.69 |
| Average from mixer | 1.26 |

If the heats of oxidation of silicon, manganese, and iron are considered,[30] we can state that the following reactions can take place.

| | Calories. |
|---|---|
| Si to $SiO_2$ | 180·0 |
| Mn to MnO | 90·9 |
| Fe to FeO | 65·7 |

$$Si + 2FeO = 2Fe + SiO_2 + 48{\cdot}6 \text{ calories.}$$
$$Mn + FeO = Fe + MnO + 25{\cdot}2 \text{ ,,}$$

so that manganese and silicon can reduce iron from ferrous oxide. With silicon and manganous oxide, on the other hand, there is a small negative heat balance:

$$Si + 2MnO = 2Mn + SiO_2 - 1{\cdot}8 \text{ calories.}$$

but if the excess MnO present unites with the silica to form manganese silicate, the heat of formation of this being positive, allows the reaction to take place to a limited extent with the partial reduction of the MnO:

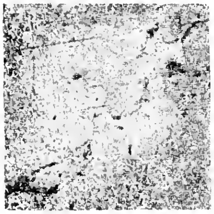
$$MnO + SiO_2 = MnO,SiO_2 + 5{\cdot}4 \text{ calories.}$$

If the monobasic silicate is formed 66 per cent of the oxide can be reduced, but if the dibasic silicate is formed only 50 per cent, so that where there is excess silicon it is the monobasic silicate which is formed. For instance, Levy[31] kept 1 per cent of $2MnO,SiO_2$ containing 30 per cent $SiO_2$ in contact with molten siliceous cast iron for thirty minutes, and on cooling the iron was enriched with manganese, and the slag contained 50.2 per cent of $SiO_2$, having been reduced to monosilicate.

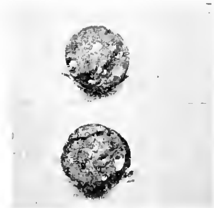
These reactions supply the explanation of the changes in composition of mixed slags. MnS rising to the surface is oxidised, and the MnO along with the FeO is reduced by silicon to form a complex slag. It is generally found that the higher such slags are in silica, the lower they are in FeO as a consequence. The ultimate end product in mixer slags would be pure manganese silicate.

Turning to the MnS which is always present in steels, when the steel is passing from the melting furnace to the ladle, or from the ladle to the mould, some of the MnS particles will have the opportunity of being oxidised by the air, and the MnO so formed will be reduced by a similar sequence of reactions to that indicated above, and will eventually become manganese silicate. It might also happen that insufficient

PLATE I.

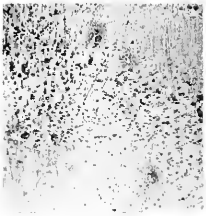


No. 1.

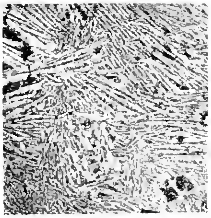


No. 2.

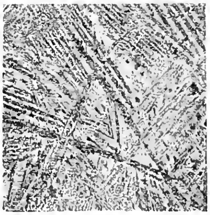
No. 3.



No. 4.



No. 5



No 6.

No. 1. × 100. Cracks originating from small inclusions.
No. 2. Fracture of tensile test piece. Bright areas are caused by discs of slag.
No. 3. × 100. Slag inclusion surrounded by light etching halo.
No. 4 × 100. Aluminium sulphide inclusion in steel.
No. 5. × 100. Rhodonite. MnO $SiO_2$.
No. 6. × 100. Rhodonite with 2.9 per cent. MgO. Reduced by one-twelfth.

[26] Metallurgical and Chemical Engineering, 1915, p. 891.

[27] Journal of the Iron and Steel Institute, 1891, No. II, p. 78.

[28] Ibid., 1892, No. II. p. 259.

[29] West of Scotland Iron and Steel Institute, 1898, p. 18.

[30] "Metallurgical Handbook," Liddell, p. 279.

time is given for the MnO to be reduced before the steel solidifies, so that from the sulphide alone there is the possibility of manganese sulphide, oxide, and silicate being found in the finished steel. The chance of reduction primarily depends on the silicon content of the steel, and so in basic steels containing low silicon there is greater likelihood that any oxides formed will preserve their identity unchanged.

Whether duplex inclusions are produced when all three products are present depends on the solubility relations of these substances, and on this aspect little work has so far been done. Stead[32] was the first to note that MnS and manganese silicates were often associated in large forgings, and he identified them by etching with dilute sulphuric acid or heat tinting. Under the microscope, on etching with dilute acid, bubbles of gas were given off by the lighter constituent, which was considered to be MnS. Manganese silicate was nearly always associated with MnS. Howarth[33] confirmed these results, and Law[34] also identified the lighter constituent as the MnS and the darker as silicate. The only work which has been done on the relation of MnS and silicate was carried out by Levy,* who stated that MnS was soluble in the molten silicate up to 50 per cent, and in the solid condition the sulphide particles were just visible when 1 per cent was present. With higher percentages dendritic crystals appear which are much lighter in colour than the silicate. Slags containing 50.5 per cent $SiO_2$ could contain up to 1.5 per cent of MnS in solid solution.

These results have been confirmed by the author. For this purpose manganese sulphide was made by passing $H_2S$ over pure manganese carbonate at about 900 deg. C. The resulting black mass had the composition:

| | Per Cent. |
|---|---|
| MnS | 78·7 |
| MnO | 21·2 |

and for the purposes here it was unnecessary to make it purer. Melts were made of silicate containing—

| | Per Cent. |
|---|---|
| MnO | 50·2 |
| $SiO_2$ | 45·8 |

and 1.5, 2, and 4 per cent of MnS. With 1 per cent the solution was complete, with 1.5 per cent only two minute specks could be seen in all the section, and with 2 per cent the specks of MnS were numerous. The limit of solubility of MnS in silicate is about 1.5 per cent, when silicate has the composition commonly occurring in non-metallic inclusions. In these experiments the sulphide particles were very much lighter than the silicate ground mass.

## Manganese Silicates.

Only two silicates of manganese are known to mineralogists — rhodonite, $MnO.SiO_2$, and tephroite, $2MnO.SiO_2$. Among metallurgists others have been surmised between these two, but the $MnO—SiO_2$ diagram so far as it has been worked out only confirms the existence of the two silicates which occur naturally, and it is unlikely that any others exist.[35] The diagram is reproduced in Fig. 4. Microscopical examination confirms the thermal results, and between the pure compounds there is visible a badly defined mixture of the two constituents which, however, contains no resemblance to the eutectic structures met with in metallic alloys. The eutectic mixture solidifies about 1180 deg. C. and has the composition 41.0 per cent $SiO_2$, and 59.0 per cent of MnO. It is curious that most of the silicates isolated from steels have approximately the same percentage of silica, so that they belong to the class most easily fusible, the presence of alumina and ferrous oxide making up for the deficiency in manganese oxide (Table I.). Various

TABLE I.

| | $SiO_2$. | MnO. | FeO. | $Al_2O_3$. | Authority. |
|---|---|---|---|---|---|
| A | 40·8 | 33·6 | 3·3 | 18·3 | Saniter |
| B | 46·6 | 48·1 | 1·9 | 3·4 | Stead |
| C | 37·7 | 43·4 | 18·4 | ... | Jager |
| D | 41·8 | 43·9 | 3·5 | 10·1 | McCance |
| E | 38·5 | 37·3 | 1·4 | 18·4 | " |

mixtures of pure $SiO_2$ and $MnCO_3$ have been melted up and the mass examined under the microscope. The mixtures containing less than about 40 per cent MnO were of a brown color and were opaque, but with higher contents they were very readily converted into brown transparent glasses if the cooling was at all rapid. Under the microscope the opaque varieties were characterised, on etching with reagent B, by a very decided crystalline structure, which was identified ultimately as rhodonite. Micros. Nos. 5 and 6, Plate I., give the typical appearance, consisting of long thin crystals in interlacing masses. Naturally occurring rhodonite crystallises in the triclinic system. Compared with other compounds with which it is found associated in ferrous metallurgy it has a very dominating crystalline habit. A melt containing approximately:

| | Per Cent. |
|---|---|
| $SiO_2$ | 11 |
| MnO | 15 |
| FeO | 74 |

showed under the microscope the pronounced needles of rhodonite dominating the background, although iron silicate was present and iron oxide in excess. Acid open-hearth slags which have been slowly cooled show also when fractured long radiating crystals with the form of rhodonite, although less than 20 per cent of the latter may be present. This silicate is the one met with in every case where the ratio of the amounts of $SiO_2$ to MnO is greater than about 1½, so that it includes nearly all the slag products met with in practice.

The more basic silicate $2MnO.SiO_2$ when found naturally occurring is known as tephroite and crystallises in the rhombic system. Artificially prepared this silicate shows a strong tendency to form a brown glass devoid of structure. When crystallised it has a greenish colour in the absence of iron, and this colour is

[31] Iron and Steel Institute: Carnegie Scholarship Memoirs, 1911, vol. III, p. 304.

[32] The Iron and Steel Magazine, 1905, vol. ix, p. 105.

[33] Journal of the Iron and Steel Institute, 1905, No. II, p. 310.

[34] Ibid., 1907, No. II, p. 96.

* Loc. cit.

[35] Doerinckel, Metallurgie, 1911, p. 201

often noticeable in inclusions of sufficient size. Howarth [36] drew attention to this peculiarity of the inclusions found in nickel steel. In mixer slags well-defined crystals of rhombic form have been isolated whose composition was[37]:

| | | | | |
|---|---|---|---|---|
| $SiO_2$ | 22·05 | Corresponding to | $2MnO.SiO_2$ | 63·75 |
| MnO | 56·95 | | $2FeO.SiO_2$ | 11·80 |
| FeO | 14·60 | | FeO | 6·2 |
| S | 8·81 | | MnS | 19·5 |

A double silicate of the form of $2(MnFe)O.SiO_2$ crystallising in the rhombic system is known to mineralogists as knebbelite, which points to the corresponding silicates of iron and manganese being isomorphous.

Under the microscope such glassy slags as occur with high percentages of manganese show no structure. However, by maintaining them at about 1100 deg. C. for some time they can be induced to crystallise, and it is very interesting to watch the crystallites grow after each heating, and no doubt if they were kept for a sufficiently long time they would ultimately form one crystal. A peculiarity is that any $Fe_2O_3$ which they contain is deposited by this treatment and takes the characteristic form of magnetite, while there is a suspicion that the $Al_2O_3$ present is deposited as skeleton crystals of some form of spinel.

The author has found this heat treatment of slag material of great use in studying inclusions.

### Iron Oxide Scales and Silicates.

Considering the importance of iron oxides and silicates in metallurgical operations, it is surprising how little is known concerning the constitution of their mixtures.

The naturally occurring oxides are so well known as to require no mention here. Mixtures of $Fe_2O_3$ and $Fe_3O_4$, both natural and artificial, have been studied by Sosman and Hostetter,[38] and they have come to the conclusion from an examination of the magnetic properties and the dissociation pressures that these two oxides form a continuous series of solid solutions. No work has yet been done on the oxides whose compositions lie between $Fe_3O_4$ and FeO, although these are the mixtures of greatest practical importance. FeO does not seem to be able to exist in the pure state, it is always accompanied by $Fe_3O_4$, and all slags containing iron show the presence of both.

Occurring naturally there are two silicates. Fayalite, $2FeO.SiO_2$, crystallises in the rhombic system and is consequently isomorphous with tephroite, and in fact it generally contains a proportion of manganese on analysis. It has been found in many rocks associated with magnetite. About the other silicate grunerite, $FeO.SiO_2$, very little is known with certainty. Originally described by Gruner,[39] it also has been recognized in certain rocks and noted on rare occasions among the Lake Superior ores.

Hofman[40] has studied the formation and fusing temperatures of some mixtures of FeO and $SiO_2$, but his results in the light of the author's investigations are wholly misleading if used as a basis for deducing the equilibrium relations between ferrous oxide and silica.

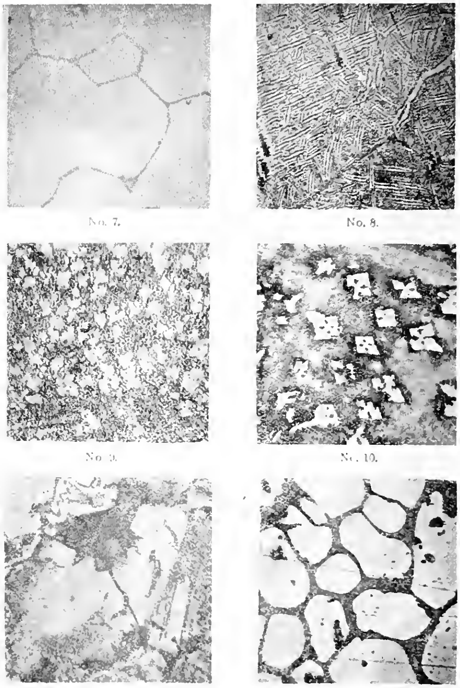
Since a consideration of the iron oxides to be found under works conditions leads naturally to the study of the iron silicates, the same order will be followed in their consideration in this section.

Magnetite has the theoretical composition:

| | Per Cent. |
|---|---|
| $Fe_2O_3$ | 69·0 |
| FeO | 31·0 |

and crystallises in well-defined octahedrons, while it is of course, strongly magnetic. The scale which forms on the surface of forgings during heating under oxidising conditions is also magnetic, but the percentage of FeO is much higher than that of magnetite, and in addition there is a certain amount of manganese and silica derived from the steel. A typical analysis of a

PLATE II.



No. 7. No. 8. No. 9. No. 10. No. 11. No. 12.

No. 7. × 100. Iron oxide scale containing 0.3 per cent. $SiO_2$.
No. 8. × 100. Triangular structure of iron scale.
No. 9. × 100. Crystals of magnetite (?) in iron scale.
No. 10. × 500. Magnetite crystals in slag.
No. 11. × 500. Crystals of FeO in iron scale.
No. 12. × 250. Iron scale containing 3.84 per cent $SiO_2$.

Reduced by one-twelfth.

[36] Loc. cit.

[37] Kosman, Stahl und Eisen, vol. xi. p. 904.

[38] American Institute of Mining Engineers, 1917, p. 907; American Chemical Society, 1916, p. 807.

[39] Comptes Rendus, vol. xxiv. p. 794.

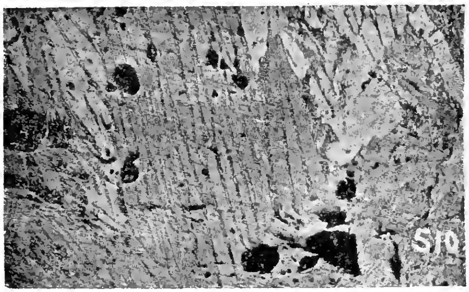
[40] Transactions of the American Institute of Mining Engineers, 1899.

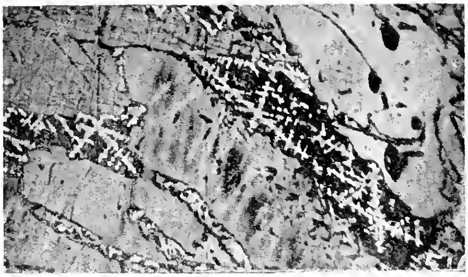
forging scale is given in Table II., A, and this composition corresponds to about 48 per cent magnetite, and the remainder FeO. Under the microscope it consisted of large bright grains which had a darker constituent between them, and since the latter was attacked by hydrofluoric solutions, it was suspected to be a silicate. This was confirmed when its amount depended on the percentage of $SiO_2$ present in the scale (Plate II., No. 7).

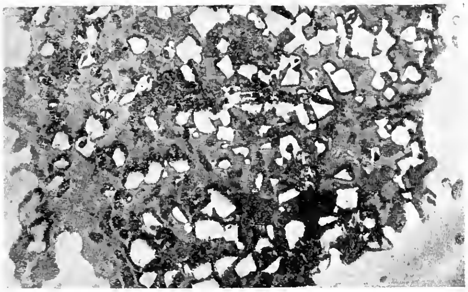
**Table II.**

| | $SiO_2$. | FeO. | $Fe_2O_3$. | MnO. | P. |
|---|---|---|---|---|---|
| A | 0·30 | 65·52 | 33·28 | 0·71 | ... |
| B | 1·58 | 66·74 | 30·40 | 0·64 | ... |
| C | 3·84 | 70·06 | 25·35 | 0·74 | ... |
| D | 4·75 | 73·93 | 20·50 | 0·79 | ... |
| E | 16·0 | 64·94 | 6·80 | 2·92 | 1·40 |
| F | 19·0 | 63·29 | 5·60 | 2·83 | 2·68 |
| G | 31·0 | 64·08 | 3·20 | nil | ... |

PLATE III.







Nos. 14 — 15 — 18.

No. 14. × 100. Fayalite 2FeO $SiO_2$ in melt containing 31.0 per cent. $SiO_2$, showing decomposition.

No. 15. × 500. Decomposition products of Fayalite.

No. 18. × 250. Ferrous oxide and Grunerite in non-metallic inclusion,

On etching deeply with reagent B, the oxide was attacked and a structure developed. The part of the scale next the steel showed beautiful interlacing needles, somewhat akin to a martensitic structure, the angle between the needles varying from 60 deg. to 90 deg. (Plate II., No. 8).

On the outside surface—that is, where the more oxidising conditions would exist—distinct crystals were isolated with evidence of a very fine granular structure in between (No. 9) whch may be a entectic. Though unable to state definitely what the crystals are, from their resisting power to the acid, their general shape and their presence only in the portions exposed to the more oxidising conditions, it is probable that they are crystals of magnetite. When they occur in slags, crystals of magnetite have a very definite form (No. 10), being square in outline, and they develop only along the diagonals, grouping themselves in rows with their diagonals all pointing in parallel directions.

In scales containing a much lower percentage of $Fe_2O_3$ on the other hand, deep etching produces rather indefinitely bounded crystals of FeO (No. 11), which, judging from the extent of the scratching by the polishing abrasive, seem to have a relatively greater hardness than the background.

In slab reheating furnaces the scale which is formed fuses and is generally allowed to drain away from a cinder-hole at the back of the hearth level into a slag pot, and samples of such fused scale have been selected at various times for analysis and sectioning. Three samples are given in B, C, and D, Table II., which had increasing amounts of $SiO_2$, a fact easily recognizable under the microscope by the increase in the amount of dark etching constituent. A photo of C is given (No. 12), and also one of an artificial mixture containing 7 per cent $SiO_2$ (Plate IV., No. 13).

A large number of melts have been made containing varying proportions of $SiO_2$, and it may be said at once that Hofman's results are not borne out and that the relations of FeO and $SiO_2$ are very complicated. To begin with, it will be noticed that from the analyses of the first four scales, as the percentage of $SiO_2$ increases the amount of FeO also increases, and that of $Fe_2O_3$ gets less. There seems to be a physical equilibrium between these three substances wholly independent of their chemical grouping.

As the masses of iron silicate increase it is noticed that they are no longer homogeneous, but are interspersed with strings of a darker etching constituent which has a granular appearance under low powers. This is shown in Plate III., No. 14, taken from a melt containing 31 per cent $SiO_2$, corresponding nearly to pure fayalite. Under high powers this constituent is found to consist of a background of fayalite in which there are strings of crystallites of ferrous oxide and magnetite (Plate III., No. 15), and another still darker constituent which is homogeneous, and which in places seems to form a eutectic structure very similar to that of iron phosphide and iron. As the silica increases the quantity of this darker material also gets greater until it reaches a maximum in the neighborhood of 45 per cent. (Plate IV., No. 16), the composition of

grunerite $FeO,SiO_2$. This latter occurs in well-defined crystals or groups of crystals with a dark brown colour which are quite homogeneous, and this knowledge permits of its easy identification where crystallisation has been possible.

As it was thought that lack of time during cooling did not allow of equilibrium conditions being attained, specimens of silicate containing 29 per cent of silica were heated to various temperatures for three hours and examined. No change took place until 1150 deg. C. was reached, when the specimen cracked badly, evidently due to volume changes, while the smaller crystallites of FeO and of grunerite joined up with those of their kind to form larger and better-defined crystals. In no case, however, has it been possible to get homogeneous fayalite, and this latter case was the nearest approach to homogeneity attained. On cooling mixtures of FeO and $SiO_2$, corresponding to the composition of fayalite, the FeO separates first and is afterwards reabsorbed to form fayalite, but the absorption is never complete, and evidence of this fact gives rise to a characteristic appearance of fayalite which serves at once to identify it where it occurs.

From the microscopic study, the $FeO\text{-}SiO_2$ diagram seems to be of a somewhat similar type to that of MnO and $SiO_2$, though the evidence concerning the eutectic is very doubtful. The presence of free FeO and fayalite in melts containing even 60 per cent $SiO_2$ seems to support the view that the eutectic occurs between grunerite and silica, while it certainly shows how difficult it is to attain equilibrium conditions.

With samples containing low silica which have been very quickly cooled, a structure of FeO and fayalite which might easily be taken for a crystalline eutectic can be produced, and it is of interest to note that under these conditions the fayalite is homogeneous and shows no decomposition under a high-power examination.

In acid open-hearth slags it is fayalite which is present (see next section).

Rhodonite and fayalite are practically insoluble in one another in the solid state, and mixtures can be easily distinguished under the microscope, though in the liquid state they are soluble to a considerable extent. A mixture of 80 per cent rhodonite and 20 per cent of fayalite after melting cooled to a brown glass without structure. On heating to 1100 deg. C. for three hours, however, crystallisation took place, and a section on etching showed darker crystals of iron silicate on a lighter background, and also considerable quantities of ferrous oxide. This was so unexpected that it was repeated more than once, but always with the same result, though fayalite itself showed no such tendency, but on the contrary, showed some power of reabsorbing the FeO. It was concluded that in the presence of MnO fayalite breaks up into free FeO and grunerite $FeO,SiO_2$. The grunerite can be recognised by its distinct crystalline outline and smooth surface.

It was thought that this action might throw some light on the composition of inclusions which were structureless, if they happened to belong to the range of composition in which this action took place, so pieces of steel known to contain inclusions were slowly heated to 1200 deg. C., and after cooling down they were sectioned and lightly etched with reagent A. In many of the larger inclusions crystallisation had taken place, and a duplex structure had resulted. Plate IV., No. 17, shows an inclusion of grunerite crystals on a background of manganese silicate, and Plate III., No. 18, is similar, with the addition of numerous crystals of ferrous oxide. The presence of this oxide cannot be taken as evidence that it had existed independently in the steel, however, since slag inclusions if they had the correct composition would act in a similar manner.

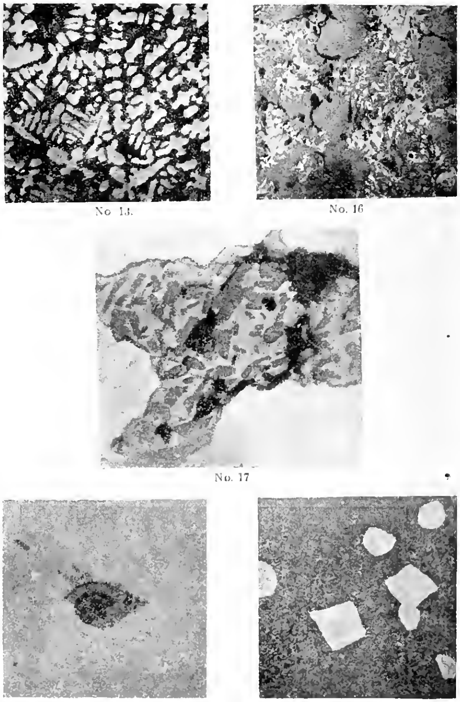
Another interesting inclusion is given in Plate IV., No. 19, showing a globule of iron silicate which has been partially reduced to manganese silicate by interaction with the manganese in the steel. It has evidently been in motion when the metal solidified.

## Acid Open-Hearth Slags and Their Reduction Products.

At the present time very little is known regarding the constitution of open-hearth slags, and the following is a summary of some of the work on this subject which the author is at present engaged on.

Acid open-hearth slags are essentially mixtures of

PLATE IV.



No. 13. No. 16.

No. 17.

No. 19. N. 20.

No. 13. × 250. Iron oxide containing 7 per cent. $SiO_2$.

No. 16. × 75. Grunerite (dark) on a background of Fayalite and Ferrous Oxide. Melt containing 45 per cent. $SiO_2$.

No. 17. × 250. Grunerite crystals in non-metallic inclusion.

No. 19. × 500. Partial reduction of iron silicate by manganese.

No. 20. × 100. Areas of glass in crystalline open-hearth slag.

Reduced by one-twelfth.

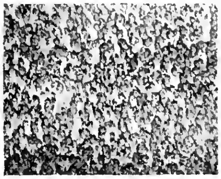
iron and manganese silicates containing proportions of CaO, MgO, $Al_2O_3$, and $Cr_2O_3$, and from what has been stated in the previous sections the manganese will exist as rhodonite, $MnO,SiO_2$, and the iron either as fayalite, $2FeO,SiO_2$, or grunerite, $FeO,SiO_2$. Crystals which have been isolated from an acid slag[41] gave the composition:—

| $SiO_2$ | FeO. | MnO. | $Al_2O_3$. |
|---|---|---|---|
| 30·75 | 60·23 | 5·10 | 2·07 |

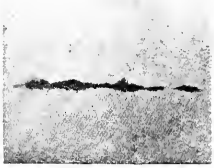
which corresponds to 85 per cent of fayalite, but microscopical confirmation is absolutely necessary before this could be definitely stated.

Slag samples drawn from the furnace and allowed to cool in the spoon show when polished an external glassy skin which may be about 1-16 inch thick, and the remainder an opaque agglomeration of crystals. Sectioned and polished under low powers there are irregular crystal outlines, some rectangular and some

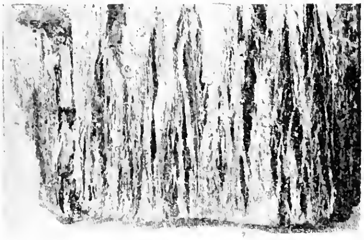
PLATE V.



No. 21



No. 21



No. 22.

No. 23.

No. 21. × 250. Acid open-hearth slag. Crystals of Fayalite (dark) in spoon sample.
No. 22. Crystallised open-hearth slag.
No. 23. × 250. Eutectic between veined silicate and Fayalite.
No. 24. × 100. Typical inclusion of slag.
Reduced by one-twelfth.

[41] Oesterreichische Zeitschrift fur Berg-und Huttenwesen, vol. xiii, p. 75.

globular (Plate IV., No. 20), which have been found to be areas of amorphous glass embedded in the crystalline matrix. The occurrence of these in the centre of the test where the cooling is slowest, surrounded by crystalline material, is peculiar and not easily explained. Under high powers after etching with reagent B, the slag consists of a light background filled with innumerable small square and irregular crystals of a dark color (Plate V., No. 21). These crystals contain the iron, and the background contains the manganese and other elements in combination with the silica, and also any excess silica. As the percentage of FeO increases the small dark crystals increase in number and ultimately join up, forming chains and masses in intimate mixture with the lighter background.

Larger masses of slag which have been allowed to cool down slowly show on fracturing radiating crystals which have the dominates that of the other substances present (No. 22). Under characteristic appearance of rhodonite whose crystalline form the microscope there are two constituents—long elongated crystals of the clear ground-mass, and an intimate mixture of this with the iron silicate (No. 23). This structure is probably a eutectic. Under high magnifications the iron silicate is found to be broken up in a manner which at once identifies it as fayalite, and there is a third constituent present as minute idiomorphic crystals with a square outline exactly similar to the crystals of magnetite shown in No. 10, and these small crystals only occur in conjunction with the iron constituent. It has long been known that open-hearth slags always contain a proportion of their iron content as $Fe_3O_4$, and the presence of magnetite under the microscope demonstrates the manner of its occurrence.

In slags containing chrome, the chromium exists as 4 or 6 rayed crystallites which do not necessarily associate with the iron and are probably chromite, $FeO,Cr_2O_3$. The presence of this constituent would explain the decreased fusibility of slags containing chromium.

These results when more fully examined may throw light on the mechanism of the reactions which take place in the open-hearth furnace.

Since the iron exists in slags as the basic silicate, it can be understood that such slags in the presence of manganese will undergo a change through the reduction of the iron by the manganese from its combination with oxygen, and this action is the key to the interactions which take place between steels and the slag particles included in them. To show definitely the importance of this action equal weights of ferromanganese finely ground and slag were heated together in a fireclay pot. About 1200 deg. C. a rapid reaction took place and the mixture frothed up, and separated into two layers on subsiding. The analysis of the slag used is given in A, Table III., and the resulting slag in B, Table III., is very largely manganese silicate, the iron content having been greatly reduced. This reaction proceeds more rapidly with a slag taken from the furnace during the boiling period which has a high iron content, than with a finishing slag comparatively low in FeO, and which is more viscous when melted. In the present case, however, a finishing slag was used.

Slag in contact with steel and slag inclusions will therefore be ultimately converted into manganese silicate if sufficient time be given for the reaction to

complete itself before the steel sets. Taking A, Table III., as a typical open-hearth finishing slag, the composition of the slag inclusion C, Table III., taken from a large forging, shows how the manganese oxide has been increased at the expense of the FeO and silica. During the teeming of steel into the moulds there is always a scum which floats on the surface of the metal, which may in certain cases consist of slag mix-

TABLE III.

| | SiO | MnO. | FeO. | $Al_2O_3$. | CaO. |
|---|---|---|---|---|---|
| A | 51·9 | 15 3 | 23·3 | 3·1 | 4·5 |
| B | 42·7 | 42 6 | 3 6 | ... | ... |
| C | 45·9 | 25·1 | 13·4 | 5 4 | ... |
| D | 40 2 | 31·2 | 11·3 | 9·4 | ... |
| E | 35·5 | 30·1 | 13·2 | 20·4 | 0·1 |
| F | 36·3 | 47 2 | 0 9 | 9·3 | 2·5 |

ed with firebrick material, the composition of which consequentliy varies between fairly wide limits. D and E, Table III, are two samples, in the latter case the alumina being particularly high. Finally, in the manufacture of high manganese steels opportunity is given for the reduction to be carried a step further, and the slag which forms is of a very basic character, the iron being almost completely reduced. This latter slag (F, Table III.) had a yellow-green color and was opaque, while it contained in addition 2.08 per cent of manganese sulphide. It was very similar in color to the inclusions noticed in plates and forgings.

Another aspect of the same question concerns the loss of manganese additions made to steel before teeming. This loss is made up of the loss due to the reduction by the manganese of any FeO dissolved in the steel, and by the variable loss of manganese occasioned by the interaction with the slag covering. This latter effect is very often overlooked and its importance scarcely realised.

Ferro-manganese, being lighter than steel, rises to the surface, where it mixes with the slag and is oxidised by the contained FeO. This action was noticed as long ago as 1891 by Addie,[42] whose analyses of the slag before and after the additions of manganese are given in Table IV., along with later results obtained by Whiteley,[43] which fully confirms them.

TABLE IV.

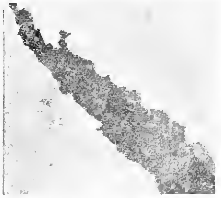
| | $SiO_2$ | FeO. | $Fe_2O_3$. | MnO. | Authority. |
|---|---|---|---|---|---|
| Before | 55·60 | 25·78 | 3 88 | 4·25 | Addie |
| After | 55·60 | 24 26 | 2 56 | 6·41 | |
| Before | 52·9 | 26·0 | . | 7·95 | Whiteley |
| After | 52·6 | 23·6 | .. | 10·30 | |

In a 50-ton charge with 4 tons of slag, if the MnO content of the slag is increased by 2 per cent. after the ferro-manganese additions, the loss of manganese owing to this cause alone would amount to 1.24 cwts., and if 0.5 per cent. had been added to the steel the percentage loss would amount to 24.8 per cent. of the manganese additions.

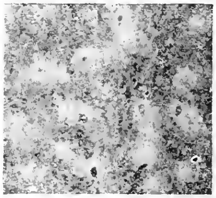
In the opinion of the author this slag reaction accounts for a considerable proportion of the loss of manganese additions, and also for the great variability of the loss from charge to charge. During the teeming this reaction still proceeds and causes a diminution in the manganese content of the top layers of steel in contact with the slag, a fact well shown during the investigation of an open-hearth charge by Morgans and Rogers,[44] and the curve connecting the average manganese content of each ingot with its position as cast is given in Fig. 5. The loss of manganese in the last portion to be cast due to the slag reaction is quite appreciable.

Under the microscope included slag is a very common defect in acid steels. It is recognised by its brown colour, which varies a little in tint and by the matte surface of the inclusion, while the boundaries are peculiarly irregular and indefinite. Slag inclusions are not plain elongated particles, but are beady in outline, and they are generally badly fissured and cracked (Plate V., No. 24).

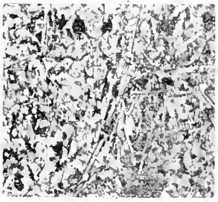
PLATE VI.



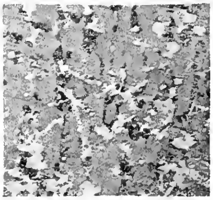
No 25



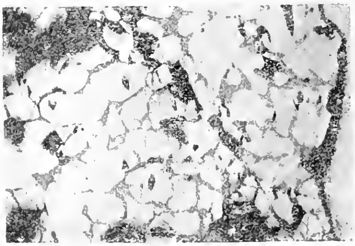
No 26



No. 27



No 28



No. 29

No. 25. × 100. Inclusion derived from ganister.
No. 26. × 100. Bath sample showing inclusions situated in phosphide areas.
No. 27. × 250. Pudding slag form cold working furnace.
No. 28. × 250. Puddling slag showing Fayalite and Ferrous Oxide.
No. 29. × 250. Inclusion in puddled iron containing about 1½ per cent $SiO_2$.

[42] Engineering, vol. lii., p. 103.

[43] Journal of the West of Scotland Iron and Steel Institute, 1917, p. 80.

[44] Journal of the Iron and Steel Institute, 1917, No. II, p. 209.

An inclusion found in a basic plate of mild steel containing

| C. | Si. | Mn. | S. | P. |
|---|---|---|---|---|
| 0·16 | 0·023 | 0·54 | 0·025 | 0·023 |

was sufficiently large to analyse, and it gave the following result:

| $SiO_2$. | MnO. | FeO. | $Al_2O_3$. | CaO. |
|---|---|---|---|---|
| 60·7 | 1·30 | 27·1 | 4·5 | 3·8 |

It is mainly a ferrous silicate, and under the microscope had a uniform dark brown colour. Etching with reagent A. however, developed two constituents which differed very little in tint but could be distinguished by the eye. The lighter one occurs as idiomorphic crystals which can be seen in Plate VI., No. 25. They were attacked by the reagent, but not so strongly as the darker constituent, and they appear to be crystals of silica. Even if the iron be present as $FeO.SiO^2$ there must be excess silica present, and when the very low percentage of silicon present in the steel is borne in mind, it is likely that this inclusion was derived from ganister which had fallen into the molten metal.

The general question arises how and when slag particles are introduced into the steel. An obvious opportunity occurs during the tapping of the metal into the ladle, when it is impossible to prevent the slag and metal from getting mixed and the slag getting broken up into small globules by the stream of metal. The likelihood is, however, that particles of slag so introduced are sufficiently large to rise to the surface. But little can be done under ordinary working conditions to prevent this happening.

During the boiling period in the furnace the slag and metal are in rapid motion and become mutually intermixed. Thus the slag samples taken at this time contain large numbers of metallic globules or "prills" which can be easily recognised. Some of these attain quite a large size, even up to 3-32 inch in diameter. In the metal the corresponding action also takes place, but is not so generally admitted, since it can only be detected under the microscope. A small sample taken from an acid open-hearth charge during the boiling period was sectioned and heat tinted after a slight etching with $HNO^3$. No. 26 shows the particles which occur in between the crystal grains where the phosphorus is also high. These particles are slag particles. They have a dark brown color, and the analysis of the sample

| S. | Mn. |
|---|---|
| 0.048 | trace. |

precludes the existence of manganese sulphide. This latter point is supported by the great difficulty of taking a sulphur print—even after thirty minutes' contact the bromide paper was only weakly coloured.

Apart altogether from the chemical influence of the slag its physical condition during the period of greatest commotion, that is, during the boiling period, must on this view have a direct influence on the amount of included slag, and since the physical condition of the slag is largely a question of its temperature and its basicity, there should be a connection between all these factors. The basicity of the slag is governed by the ratio of its silica to ferrous oxide content, since the manganese and lime content remain sensibly constant. A statistical record of one class of forging taken over a considerable period showed that the numbers which had been found defective due to non-metallic inclusions under the different conditions could be represented by the following figures, the lowest value for each class being taken as unity:

| Ratio Slag $\frac{SiO_2}{FeO}$ | Casting Temperatures. | | |
|---|---|---|---|
| | Hot. | Medium. | Cold. |
| Under 1·3 | 1·0 | 1·0 | 1·0 |
| Over 1·3 | 2·2 | 1·7 | 1·2 |

The slag ratio of 1.3 has been chosen quite arbitrarily as the result of experience, and the casting temperatures refer to a pyrometric scale in which the maximum variation which has been found to occur has been divided into three equal parts. The slag sample is taken 30 minutes after the furnace commences to boil.

From this it will be seen that no matter what the temperature of working is, a fluid slag of high iron content reduces the number of inclusions, and if other conditions are kept constant the higher the temperature of working the more important it is that the slag should have the proper composition.

The author considers that records of the slag composition and the pyrometric temperature of casting of open-hearth charges form a most valuable addition to our knowledge of the working of open-hearth furnaces, and not only yield important information by themselves but they also indicate what at the present time is so largely a question of indefinite opinion, the best conditions for working and for controlling the manufacture of steel by the open-hearth process.

**Fluxed Refractory Material.**

Since steel during its manufacture is always in contact with refractory material of some kind, it is only natural that pieces and chips of such material should get admixed with the steel and ultimately find their way into the solidified ingot.

Such pieces may be simply firebrick, such as the analysis of A, Table V., gives. This was found in the centre of a rolled bar, and the original structure of the firebrick was distinctly visible, though a small amount of iron oxide—probably derived from scale—has been absorbed. In another case the iron oxide had considerably increased (B, Table V.), and the only conjecture which can be made to account for this peculiar composition is, that the piece of firebrick which became mixed with the liquid steel had previously been saturated with iron oxide when it fell in. It had no appearance of having been slagged, but was scraped out from an internal defect in a boiler plate as a black powder.

TABLE V.

| No. | $SiO_2$. | $Al_2O_3$. | MnO. | FeO. | CaO. | Authority. |
|---|---|---|---|---|---|---|
| A | 53·0 | 28·6 | nil | 6·0 (FeO) | 0·70 | McCance |
| B | 43·7 | 24·8 | 3·2 | 26·3 | 1·3 | " |
| C | 62·0 | 22·4 | 10·4 | 2·6 | 1·1 | " |
| D | 52·8 | 27·8 | 18·4 | 0·1 | nil | Brearley |
| E | 41·2 | 28·6 | 27·0 | trace | ... | " |
| F | 28·8 | 37·5 | 29·1 | nil | ... | Neu |
| G | 44·6 | 31·7 | 20·5 | 3·3 | ... | McCance |

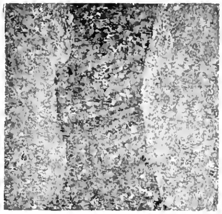
The content of iron oxide is generally small, how-

ever, though the content of manganous oxide may be considerable. Such examples as D and E, Table V., found by Brearley in ingots split open for experimental purposes,[5] contain only traces of FeO. Where aluminium has been used as a deoxidising agent it would be expected that the action of this energetic reducer might account for inclusions of the type given in Table V., but no aluminium was used in the steel from which B and C were taken, and since aluminium has almost as strong an action on MnO as FeO, it would be expected that the Al content of the inclusion would rise at the expense of the MnO and FeO. But from the examples given this is not the ease, the tendency being for an increase in the MnO to be accompanied by a decrease in the $SiO_2$, while the Al remains sensibly constant, pointing to an interaction between the Mn and MnO and the $SiO_2$ of the firebrick. Neu[6] has claimed the interaction between the aluminium and the other deoxidisers or their products, accounted for the composition of slag which has squirted out from a rail ingot during rolling (F, Table V.). The steel had additions of spiegel, ferro-silicon, and aluminium, so that in this case the claim was probably correct. But the largest number of inclusions containing alumina have been found in steels to which no aluminium has been added.

The alumina content varies between wide limits, from the 3.4 per cent. of B, Table I., to the 28.16 of E, Table V., so that the majority of such inclusions are simply mixtures of manganese silicate and firebrick material in varying proportions. Manganese silicate has a distinct affinity for $Al_2O_3$. An artificially prepared silicate containing 2.5 per cent. $Al_2O_3$ after melting in a soft clay pot had its alumina content increased to 11.5, while the silica content was actually lowered. This shows that the constituents were not dissolved in the proportions in which they existed in the clay, but that a selective solubility existed for alumina.

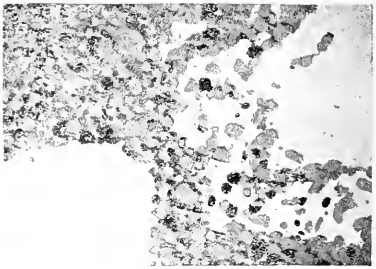
The interaction of steels containing manganese and firebrick has a distinct bearing on the wear of ladle nozzles and runners conveying steel to the moulds. A nozzle after teeming the charge will often have been widened to twice the original diameter of hole, and this excessive wear is not due solely to friction, since basic pots under the same conditions are practically unaffected. They are really slagged away through chemical action, and if examined afterwards a thin layer of brown glass about 1-16 inch thick always covers the surface in contact with the steel. The composition of such a layer is given in G, Table V., which was the slagged layer scraped from a runner. This might be formed in two ways, either through the direct reduction of the $SiO_2$ in the firebrick by the manganese in the steel, or by the slagging action the manganese in the steel, or by the slagging action of particles of manganese silicate contained in the steel as inclusions. For acid steels the probability lies with the second view, since so long as there is silicon present in the steel which can reduce MnO, as has been shown, it is most unlikely that the reverse reaction can also take place, when the conditions have not been changed. Small pieces of manganese silicate placed on firebrick and fused by means of a blowpipe flame "wet" the surface of the brick and spread rapidly over it, and any such particles contained in the steel will act in the same way to any firebrick material they come in contact with, and the slag thus formed will eventually find its way into the steel as larger or smaller globules. In basic steels, on the other hand, the absence of silicon allows the existence of free MnO,

PLATE VII.



No. 30.

No. 31.



No. 32.

No. 30. × 500. Inclusion containing about 10 per cent $SiO_2$.
No. 31. × 100. Oxide inclusion in basic steel.
No. 32. × 500. Structure of Oxide inclusion showing outer envelope of silicate.

and so there will be in this case a direct action between the MnO and the firebrick material.

### Inclusions in Puddled Iron.

Inclusions in puddled iron are generally ascribed to included slag, and it is natural to expect if such is the case that the structure of puddling slags should be similar to that of the inclusions. Samples of slags from a puddling furnace were taken during regular intervals and sectioned for examination.

The structure of the slag at the commencement of its flow over the fore plate is shown in Plate VI., No. 27, the background consisting of ferrous oxide and fayalite. The decomposition product of fayalite is noticeable as the dark etching constituent, and this contains magnetite. The composition of this slag is given in Table II., F. The needle-shaped crystals have not yet been identified. The furnace from which this slag was taken was working cold, and the similar slag from a hot-working furnace showed no evi-

[5] Journal of the West of Scotland Iron and Steel Institute, 1917, p. 84.

[6] Stahl und Eisen, 1912, p. 1647.

# EDITORIAL

## THE WAR.

A great change has taken place between last March and to-day. Then we waited with anxious hearts for a possible collapse of our own armies; now the tragedy has been transferred to the enemy. At this time when thankfulness for the successes of the Allies is the dominating feeling, we take the opportunity to sound the note of warning. The war is not yet over. We cannot afford to relax our efforts either at the front or at home. Continued preparation and production is essential both for a complete victory in the field and for a satisfactory peace.

At the moment our duty is to over-subscribe to the Victory Loan; let us make it the last that will be needed.

## IRON AND STEEL INSTITUTE.

We reproduce in this number three interesting papers which were read at the September meeting of the English Iron and Steel Institute.

The first of these: "The Influence of Heat-Déformation on the Qualities of Steel," by Georges Charpy (Paris), is of fundamental interest to those who are concerned with the design and production of steel pieces which undergo forging or rolling in their production. M. Charpy raises the question whether after all the rolling and forging of an ingot of steel, which we have always understood was so essential to the development of the best qualities of this material, really produces any substantial improvement. It seems strange after so many years of practical use of these operations that their utility should be called in question, but M. Charpy follows the scientific principle of taking nothing for granted, and fearlessly attacks this fundamental question. His conclusions are far reaching, and in general opposed to our preconceived beliefs. He shows that the reduction of an ingot by rolling does not improve its tensile strength either in the longitudinal or transverse direction beyond what could have been obtained by suitable heat treatment. The elongation and reduction of area are indeed increased in test bars taken along the length of the rolling, but they are correspondingly decreased in transverse test bars. This observation is of great importance in connection with the production of guns, because in these the greatest strain is transverse, and there is no object in improving the longitudinal quality of the steel if at the same time we are taking away from its transverse qualities. The paper is revolutionary in character and deserves closest attention.

A paper on "The Influence of Some Elements on the Tenacity of Basic Steel," by Andrew McWilliam, represents a serious attempt to render more accurate our knowledge of the effect of the various elements in steel on its tensile strength. It will be remembered that Mr. H. H. Campbell, in his work on "the manufacture and properties of iron and steel" develops a formula for calculating the strength of steel from the percentage of carbon, silicon, manganese, etc., which are present.

Mr. McWilliam has had an opportunity in his work as Metallurgical Inspector in India to obtain a large number of data on which to base his conclusions, and he has arrived at a formula which represents accurately the material with which he was dealing, and which is apparently nearly correct with regard to steel produced in other places and by different methods. Without going into the results in any detail the question may be raised whether such varying materials as open hearth steel, crucible and electric furnace steel will all be found to follow the same formula. It has always been supposed that there are real differences, such as traces of oxide, nitrogen, etc., which are not shown by the regular chemical analysis, but which, nevertheless, have an important bearing on the properties of the metal. One had also supposed that the exact mechanical treatment adopted, such as the forging of Sheffield tool steel, would produce a product superior to the ordinary rolled material, but the paper by Georges Charpy seems to show that even this may be another of the exploded metallurgical myths.

"The Principles of Open Hearth Furnace Design," by C. H. F. Bagley (Stockon-on-Tees), is not a paper which can be followed easily by the general reader, but to those who are directly interested in the construction and operation of open hearth furnaces it will be of great interest. This paper constitutes an attempt to apply accurate chemical and mechanical reasoning to the design of such a furnace. It can hardly be expected to represent the final word on so

complicated a subject, but at least is an interesting and valuable introduction to the study of open hearth design. We shall be glad to have suggestions from our readers with regard to the accuracy and application of the method.

---

Notwithstanding the pressure of his innumerable interests, Sir Robert Hadfield finds time to read "Iron and Steel of Canada," and to congratulate the publishers and editors upon the successful establishment of a journal devoted entirely to the interests of the Iron and Steel Industry. By a recent mail we received an account of an interview with Sir Robert, and also an impression of his opinions upon British Industry and German Science, and are glad to avail ourselves of this opportunity to publish his weighty opinions for the benefit of our readers.

---

## ART OF INDUSTRIAL DISCOVERY.

### British Science and the Future.

What is to be the industrial future of Britain? Into that one question so many others are packed that one could fill a column with the mere list of them. But when I went to talk to Sir Robert Hadfield, who is, I suppose, the foremost metallurgist of England, I was thinking chiefly of the future as compared with the past, and of that old dependence of ours on Germany from which the war has set us free. Shall we retain that freedom, or shall we in the coming years go back to the old ways? Have we in this country the men who can make us permanently independent of German scientists?

"I have yet to learn," said Sir Robert when I put the question to him, "that the German scientists are superior to our own. Germany never was ahead of us except in the application of knowledge. There is no evidence that Germans are, or ever were, ahead of us in research or ingenuity. The German people are very industrious. In the years before the war they proved that they were willing to spend years of work on any line that was suggested to them. They were ready to take any hint, to follow up any clue, but they have no monopoly of inventive genius.

"Their eagerness to learn has always seemed to me their chief characteristic. I know that Krupps kept an eye on every periodical in the world that dealt with steel. Their arrangements were so perfect that they could not miss any important fact that found its way into print anywhere. And that is how the Germans scored. They pressed the brains of all the world into their service, and the curious fact is that the world has been deluded into thinking that the consequent progress was solely due to the superiority of German brains.

### Life Has Been Too Easy.

"Some of us knew before the war that the British had brains of their own, but it has needed the war to bring that fact home to the mind of the nation. There is that excellent British Scientific Industries Exhibition at King's College. It has been a revelation to very many people. They had no idea that British scientists had achieved so much or that British industry was capable of so much, but the achievements of our scientists are not new, and British industry was always capable of the things which it is performing to-day. The fact is that life had been too easy for us in the past. We did not take our work seriously enough, and we did not care if others reaped where we had sown. Our scientists made discoveries and Germany exploited them, and was given the credit for them.

"In these years of war we have been compelled to learn our own power, and that exhibition is the proof that now at all events we are awake to it. Every time I have been to King's College since the exhibition was opened I have been struck by the number of people in the rooms and by the care with which they study the exhibits. There is nothing attractive about the show. There are no cinematograph displays, nor is there anything in the nature of entertainment. But there are always people going round, studying their catalogues, asking intelligent questions, taking notes, and showing the most genuine and instructed interest.

### The Obsession of Letters.

"We have suffered in the past from the obsession of letters. Oxford and Cambridge have concentrated on letters and mathematics and they have neglected science. It has been left to the local universities to rectify that error and to a great extent they have done it. In our works at Sheffield we know the value of the men who are trained at Sheffield University, and we employ many of them. The success of the local universities in turning out men apt in scientific work has made it clear that we have in England no lack of the raw material of which scientists are made.

"But the trouble is that there is so little recognition of the scientist. We live in an industrial age. Consider for a moment and think what the world would be like if you took away iron and steel. What would become of our houses, our towns, the whole fabric of our life? The world of to-day is built on a foundation and framework of steel, and the scientist is the master of steel as well as of all those other material things which play a part in life. But the scientist has scarcely any part in the governing of the country. The highest places and the greatest rewards appear to be reserved for those who are quite definitely not scientists. There is scarcely any organization at work seeking out and helping embryo scientists, and it has to be confessed that the boy or girl

who in England wins through to scientific competence —to say nothing of eminence—does so in spite of rather than because of our system of education.

"That is one of the things we have to change. This war has made plain the importance of the scientist even to those who in the past thought little of science. We owe our favourable position to-day to the fact that there have always been in England men who have devoted themselves to scientific studies and to research, very often without hope of reward, very often in the face of discouragement. But it is neither sensible nor fair that this state of things should continue. If we wish to retain our position we must set to work deliberately to cultivate our scientists, to seek them out and to train them and to cherish them.

### The Organization of Discovery.

"For there is nothing accidental about scientific discovery or invention. Scientific discovery is an art which can be cultivated as the late Dr. Gore showed in his wonderful book, 'The Art of Scientific Discovery.' Important discoveries cannot be made by rule alone, but the process of scientific discovery can be largely reduced to order and rule. And it must be obvious that the man who has been trained in the rules and practice of this art is infinitely more likely to make valuable discoveries than the untrained chance experimenter. Discoveries which win wars and establish a nation's industries are not lucky flukes. They are nearly always the results of work along certain definite lines—work which can only be carried out by men who have been trained to perform it.

"In the years to come we shall need all the discoveries, and therefore we must provide ourselves with discoverers. British scientists have always been among the foremost in the world, and we have to ensure that they always shall be. And that, it seems to me, is one of the great lessons which the war has to teach this country. In the past we left nearly everything to chance, but that will not do for the future. We cannot afford to run such a risk again, neither can we afford to allow the industries which are our strength to depend for their progress on the devotion of the few or the toil of those who are so often unrecognized and unrewarded.

"If we will do this, if we will find, train, use, and reward our own men, there should be no question of any kind of dependence on Germany in the future for scientific products or any fear of German competition in the industrial world."—H. L.

---

W. A. Janssen of the Canadian Steel Foundries, Montreal, has been elected vice-president of the American Foundrymen's Association.

## SIR ROBERT HADFIELD ON BRITISH INDUSTRY AND GERMAN SCIENCE.

### Distributed through the Official British Wireless Service, September, 1918.

The War came and found British industry dependent on Germany in many important matters. When supplies from Germany were cut off it became necessary for British industries to be self-supporting. They could no longer look for imports and partly-manufactured materials. There was no longer any possibility of obtaining from Germany the apparatus which in the past was believed to be essential, and it was seen at once that whatever England wanted done she must do for herself. For the first period of the War there were endless difficulties and not a few dangers. Alarming deficiencies presented themselves, and there were the most vexing problems connected with the manufacture of every kind of War material. With wonderful industry and ingenuity the Germans had gained for themselves the control of many of the key industries, and the position in England was intensely serious. In the hour of need British scientists, who had been neglected for so long, set to work as even they had never worked before. The problems that had been allowed to accumulate were tackled one by one and solved, and to-day the old dependence on Germany has vanished. But there are many people, and especially in Germany, who believe that it will return. The German scientist does not suffer from any lack of modesty. Before the War he had come to believe that he was essential to the progress of the world, and he still cherishes that comfortable faith.

It happens that there are people in England who do not share that view and who consider that they have the best of reasons for refusing to share it. Among them is Sir Robert Hadfield, England's foremost metallurgist, whose work in connection with manganese steel is as well known and as highly valued in Germany as it is in England. Speaking to a correspondent of the British Wireless Service, Sir Robert said:—

"Many people have a tendency to attribute to Germany an innate superiority in science as compared with this country. In my opinion that superiority does not exist. On the contrary, our natural capacity is, I am convinced, greater than theirs, and the many instances in which our achievement has also been greater are the best guarantee for our future success.

"In my own line of research—the science of metallurgy—I say without hesitation that Germany's advance has been based almost entirely upon British, French and American inventions and practice. But for these Germany could not have reached the strong position she has done. And her thanks for knowledge which the rest of the world has bestowed upon her are

displayed by an exhibition of barbarism such as the world has never seen before.

"After long experience, I am convinced that we have never been indebted to Germany for a single basic principle. At my Company's works in Sheffield, employing some 15,000 workers, and where most of my research work extending over thirty years has been carried out, I am not aware that we have any German process or apparatus in use. Of course, I fully appreciate Germany's energy, perseverance, and devotion to science, but an equal tribute can be paid to other nations including our own. In respect to scientific progress in metallurgy we are much indebted to France, but we owe no such debt to Germany. The Bessemer process, from which Germany has derived so much benefit, was certainly not invented in Germany. The discovery of the basic steel process was also due to our chemists, Thomas, Gilchrist and Snelus, and to M. Pierre Martin in France. It is to this process that Germany is in fact largely indebted for her developments in the production of cheap steel. Moreover, Germany obtained most of her ideas about metallurgical plant from the streams of Germans who visited America to pick up what information they could. There is nothing improper in that method of acquisition, but it is copying and not originating. While fully acknowledging the hard work and perseverance of the Germans, I must insist that I have never found in them anything indicating intellectual or inventive superiority.

"The War has compelled us to realize the value of our own men, and it has also taught us something of the resources of the British Empire. If you go to the British Scientific Products Exhibition you will have ample proof of what England has done in these years of war, and that proof, together with the history of the past, is the promise for the future. Within the Empire we have unparalleled stores of raw material of all kinds, the extent and value of which we are only now beginning to appreciate. In our own country and among our own people we have such a wealth of scientific ability as to render us permanently independent of Germany. There should not in the future be any question of German domination of British industries."

The above statements have been handed to the representatives of British Wireless authorities and have by them been very widely circulated throughout the British Empire.

We were not asked, officially or unofficially, to take cognizance of the above printed statements, but could not resist an opportunity of such value, and requote Sir Robert:—"In my own line of research—the science of metallurgy—I say without hesitation that Germany's advance has been based almost entirely upon British, French and American inventions and practice. But for these Germany could not have reached the strong position she has done." And again, "After long experience, I am convinced that we have never been indebted to Germany for a single basic principle." With authoritative opinions such as these, backed up with irrefutable evidence, and a fixed determination to foster education in every conceivable way, none need fear for our future in the application of science and art to manufacturing industries.

---

## METALLURGICAL CLASSES AT McGILL UNIVERSITY.

One effect of the epidemic of influenza has been, as a precautionary measure, to close McGill University in common with other colleges and schools, and in consequence of this the extension classes in Metallography and Iron and Steel Metallurgy have been postponed until the re-opening of the University.

Laboratory instruction in Metallography is to be given by Messrs. C. F. Pascoe and H. J. Roast. The course is to consist of fifteen evenings, and will be held on Monday of each week. It is now intended to begin the course on Monday, the eleventh of November.

The course of lectures by Mr. W. G. Dauncey, on the Metallurgy of Iron and Steel has been arranged for Thursday evenings, and this will probably begin on Thursday, the fourteenth of November.

Notice will be given in the daily press when these classes are about to commence.

Dr. Stansfield has already received a number of applications for the course in Metallography, and any others wishing to attend this course should apply promptly as the accommodation is limited.

---

In the May issue of Iron & Steel a paper was published entitled "Five Ways of Saving Fuel in Heating Houses."

A somewhat ingenious method for accomplishing this purpose with Hot Air Furnaces came to our notice a few weeks ago, and as this seems to be one of the chief objects in our lives just now our readers may be interested in it. This sixth way of saving fuel consists simply in putting a small electric fan over the cold air or intake register in the house, thus creating a forced draught through the house, and giving a very much better circulation of warm air. Many houses have a small fan, used for ventilation during the summer months, that is usually out of service for the winter; and this can very simply and at a small cost be made to save coal and also to keep the house more comfortable. One who has used this method for some time reports very satisfactory results.

---

The new Service Building for the Dominion Foundries & Steel Co. is about completed. The concrete work will be finished in a few days, the brick work, windows, and glazing are also well advanced.

# Influence of Hot-Deformation on the Qualities of Steel

By GEORGES CHARPY (Paris).

**English Iron and Steel Institute, Sept. 1918.**

It is pretty generally admitted that, in order to obtain the maximum qualities which a steel is capable of developing, it is necessary, after having run it into ingots, to subject it, by forcing or rolling at a high temperature, to a certain and important amount of deformation. It is unnecessary in this connection to go into the history of the subject; it is sufficient to quote the following passage from Harbord and Hall's "Metallurgy of Steel:" [1] "The squeezing exerted on the exterior during the process of working much improves the quality by pressing the particles into more intimate contact, and thus has a most important effect on the metal apart from its mere reduction in form or size."

In France many of the official specifications lay it down that in order to obtain certain parts it is necessary to effect, by means of forging, a reduction of the initial section of the ingot, equivalent to a given figure. These conditions are expressed as the "coefficient of working," which is equivalent to the ratio of the initial section to the final section, or, what amounts to the same thing, the ratio of the final length to the original length. The minimum values assigned to this "coefficient of working" are generally 3 or 4, and sometimes higher.

The same prepossession is to be noted in the above-quoted article by Mr. Hall, who says, in the paragraph entitled "Ingots for Forgings": "It may be taken as a general rule that no ingot should be less, under any circumstances, than one and a half times the diameter of the shaft intended to be made from it, while for work of any importance two diameters should be the minimum. The ingot used is generally three or four times the diameter of the finished shaft."[2] However, in his treatise on the "Metallurgy of Steel," Professor Howe, after having carefully discussed the different facts which would help to determine if hot-working has a "special effect" apart from that which may be exerted by the heat treatment, concludes that: "Cumulatively, then, the evidence raises a presumption in favour of the view that the supposed 'special effect' of kneading and pressure as such does not exist or is relatively unimportant,"[1] and quotes the opinion of Tchernoff, who said that he had verified his belief that "the effects of forging can be produced by heat treatment."

The question is one, therefore, that appears to deserve examination afresh, and to be made the object of systematic experiments, the more so as the conclusions which may be arrived at may lead to important modifications in the practice of manufacturing large forgings.

The experiments in question will, however, be difficult, and will necessitate numerous precautions in order to enable practically definite conclusions to be arrived at. We know, as a matter of fact, that a steel ingot is not, and cannot be either homogeneous or isotropic. The properties of the metal, in the absence of any inclusion or of any cavity, vary, in a continuous manner, from the axis to the surface and from the top to the bottom of the ingot. It is therefore impossible to have two pieces of steel, which have undergone different degrees of deformation by forging, rigorously identical both as to chemical composition and initial structure. It is possible, however, to get an approximate solution sufficient to form the basis of an opinion, on condition of taking certain precautions, on the nature of which it will be wise to lay some little emphasis.

## I.

It should be noted at the outset that in order to study the influence of hot-working on the properties of steel, it is necessary to take into consideration the local deformation undergone at the very point from which the test-piece intended to represent the quality of the metal is to be taken. If the external form of the finished piece be the only guidance afforded in this direction, it should nevertheless be possible to assume that the deformation has been uniform, at least in certain well-determined localities. This simple remark is sufficient to exclude, from systematic experiments, the use of pieces obtained by forging under the hammer or the press, at any rate under ordinary conditions. The discontinuous action of such appliances will indeed necessarily produce extremely variable local deformations. The successive compressions which allow of there being effected, under the forge or the hammer, the shaping of a block of metal, impart, to a given point in the ingot, a highly complicated path, in the course of which it alternately recedes and approaches the axis, the relative displacement of two neighbouring points being even much more irregular. It is only necessary to watch an ingot being forged under the hammer or the press, bearing in mind what has just been said, to realise the great importance of the local deformation: it is more difficult to follow them exactly. An approximate value may be assigned to the variations by making datum marks on the ingot. Amongst the numerous experiments carried out on this subject, which is a little beyond the scope of this paper, two only will be quoted; one, in which the datum points were traced on the exterior surface of the ingot and could be followed during the process of forging ,and the other in which the datum points could be fixed in the actual interior of the ingot and could be discovered by sectioning the piece, on the conclusion of the forging.

Fig. 1 shows the successive dimensions given to a steel bloom, having a square section of 550 × 550 millimetres, during the process of forging it down in the press to a section of 250 × 250 millimetres. Equidistant datum points were marked on two of the faces. Their relative positions, after the different shaping passes, are marked on the corresponding figures. It is easily seen that they have diverged by variable amounts, and the relative coefficients of working have varied, during one forging and another,

[1] London, 1907, p. 284.

[2] Ibid., p. 458.

[1] P. 249.

After the first two forgings the average coefficient of working is 1-5. The particular coefficients in region indicated by datum points are as follows:

Table A.

| | | | | |
|---|---|---|---|---|
| $\frac{A_1B_1}{AB} = 1{\cdot}38$ | $\frac{B_1C_1}{BC} = 1{\cdot}78$ | $\frac{C_1D_1}{CD} = 1{\cdot}32$ | $\frac{D_1E_1}{DE} = 1{\cdot}50$ | $\frac{E_1F_1}{EF} = 1{\cdot}60$ |
| $\frac{A'_1B'_1}{A'B'} = 1{\cdot}28$ | $\frac{B'_1C'_1}{B'C'} = 2{\cdot}15$ | $\frac{C'_1D'_1}{C'D'} = 1{\cdot}30$ | $\frac{D'_1E'_1}{D'E'} = 1{\cdot}34$ | $\frac{E'_1F'_1}{E'F'} = 1{\cdot}50$ |

1 [The author uses, in this connection, the word *étirage*, which, when expressed as a ratio, has been translated into "coefficient of working." For the verb *étirer*, the phrase "drawn down" has been used as best expressing the author's meaning.—*Note by* TRANSLATOR.]

After four forgings the total coefficient will be 3, and, in respect of the component coefficients:

Table B.

| | | | | |
|---|---|---|---|---|
| $\frac{A_2B_2}{AB} = 2{\cdot}12$ | $\frac{B_2C_2}{BC} = 5{\cdot}4$ | $\frac{C_2D_2}{CD} = 3{\cdot}20$ | $\frac{D_2E_2}{DE} = 1{\cdot}69$ | $\frac{E_2F_2}{EF} = 2{\cdot}80$ |
| $\frac{A'_2B'_2}{A'B'} = 2{\cdot}65$ | $\frac{B'_2C'_2}{B'C'} = 5{\cdot}4$ | $\frac{C'_2D'_2}{C'D'} = 1{\cdot}80$ | $\frac{D'_2E'_2}{D'E'} = 1{\cdot}80$ | $\frac{E'_2F'_2}{E'F'} = 3{\cdot}3$ |

Finally, after six forgings, the total coefficient of working is 4-8, and the component coefficients are as follows:

Table C.

| | | | | |
|---|---|---|---|---|
| $\frac{A_3B_3}{AB} = 2{\cdot}78$ | $\frac{B_3C_3}{BC} = 7{\cdot}30$ | $\frac{C_3D_3}{CD} = 4{\cdot}10$ | $\frac{D_3E_3}{DE} = 2{\cdot}75$ | $\frac{E_3F_3}{EF} = 3{\cdot}8$ |
| $\frac{A'_3B'_3}{A'B'} = 4{\cdot}38$ | $\frac{B'_3C'_3}{B'C'} = 7{\cdot}30$ | $\frac{C'_3D'_3}{C'D'} = 2{\cdot}37$ | $\frac{D'_3E'_3}{D'E'} = 5{\cdot}6$ | $\frac{E'_3F'_3}{E'F'} = 4{\cdot}4$ |

The component coefficients, the differences in which would be still more greatly accentuated if the datum points were closer together, already differ by considerable amounts from the average coefficient of working.

In another experiment an attempt was made to follow the deformations in the interior of the metal, a block of steel cylindrical in shape, with a diameter of 1-100 metre, and a length of 1-450 metre being employed. Two holes were bored in this 60 millimetres in diameter, and 0.165 metre below the outer surface. These carefully drilled holes were plugged by a series of small cylindrical rods 40 millimetres in length, machined to exactly the same diameter, and forcibly driven home by means of screw plugs. These cylinders were prepared from two different steels, one having as closely as possible, the same composition as the large block, and the other a composition which differed therefrom only in respect of having a somewhat higher percentage of manganese, the cylinders made from these two types of steel being alternated. This arrangement was selected in order to obtain a practically homogeneous block within which could be detected, after deformation, two lines orginally rectilinear and graded in portions of equal length. The two steels employed for the little cylinders could, as a matter of fact, be regarded as having, at the temperature of forging, practically identical mechanical properties, while, on the other hand, it would be easy to detect them, after sectioning, by moistening the metal with tincture of iodine, which would strongly blacken the portions higher in manganese.

The block was forged under a 4000-ton press and drawn down, in eight successive forgings into a cylinder 525 millimetres in diameter and 3.280 metres in length. The forging thus obtained was then sectionised, in the cold, along the diametrical plane cutting the two holes. The latter having undergone, during the forging, a slight torsional motion, it was found necessary to machine up the section and make it somewhat oblique in order to follow the axis of the holes. This operation was carried out easily enough by employing the iodine tincture to bring out the manganiferous cylinders which had become welded to the rest of the metal without any apparent break in their continuity, the mass represented in Plate I. being thus ultimately obtainew. The positions of the cylinders could be detected very accurately, and have been plotted in Fig. 3. The surfaces of demarcation of the cylinders are

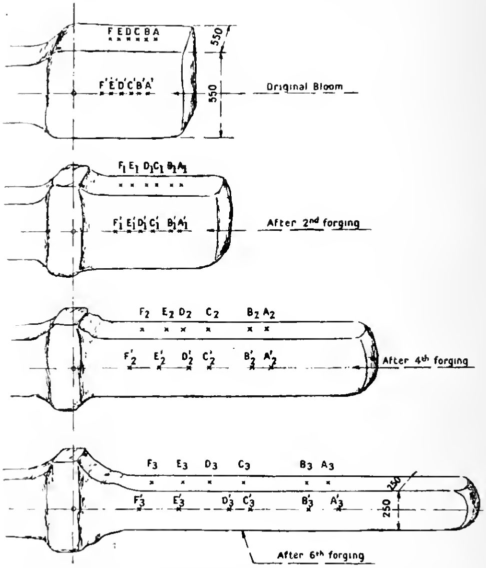



FIG. 1.—In the above it is possible to follow, during the course of forging, the displacements undergone by two series of six punch marks A B C D E F and A' B' C' D' E' F' struck at equal distances apart and in the centres of the two adjacent faces of a bloom 550 × 550 millimetres, parallel with the edges of the bloom. If the deformations due to forging occurred uniformly over the whole length of the piece the punch marks would remain equidistant throughout the operations.

It is easily seen that this is not so. From the second forging the partial coefficients vary from 1·38 to 1·78 in the upper surface and from 1·28 to 2·15 in the lateral surface, after the sixth pass the partial coefficients vary from 2·75 to 7·3 in the upper surface and from 2·37 to 7·3 in the lateral surface for a total coefficient of working of 4·8.

The drawing out is therefore not a definite or uniform characteristic of a forging.

Fig. 1.

perfectly distinct and allow of its being seen how, during the course of forging, the planes perpendicular to the axis have been deformed; there have been traced by dotted lines in Fig. 3 the approximate forms that can, in this way, be attributed, after forging, to sections originally plane. These tracings suffice to show, without its being necessary here to record the numerical measurements, the enormous differenees in the local deformations which have been realised in regions corresponding with different parts of the surface. Apart from local inequalities due to the discontinuous mechanism of forging, which have caused the axes of the cylinders to approach and to recede from the surface instead of remaining parallel with the generating axes, it is highly interesting to note what has taken place at the extremities, where, as is natural, the phenomena is particularly disturbed. The free end is formed, as might be foreseen, by the folding

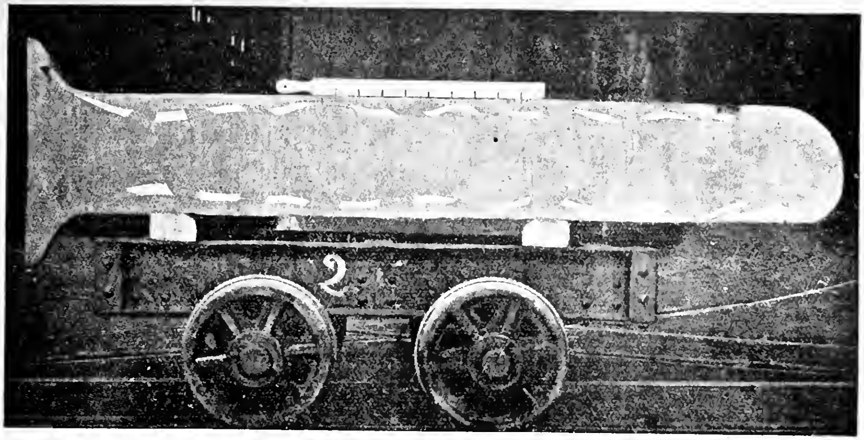


Plate I, Fig. II.

Manganiferous cylinders welded to original metal.

back of the base of the original cylinder, which thus forms an important part of the cylinder surface. From the casting end and in the immediate vicinity of the undrawn-down portion of the ingot, a change has taken place in the direction of the curve of the deformed transverse sections, which produces a profound modification in the elongations realised at varying distances from the axis. This phenomenon occurs markedly in pieces which are drawn down from both ends in succession, as is very generally done, and in the median regions of such pieces which there is very seldom any occasion to examine.

If, instead of taking the very simple instance of a cylinder, transformed into another cylinder, more complicated forgings be taken into consideration, such as are involved in many ordinary pieces, it will be perperfectly evident that the local information will be infinitely diverse.

It may therefore be taken as an established fact that in a forging the deformation is very far from being uniform, and it is useless, therefore, to attempt to bring out clearly in evidence the effects of hot-working on the mechanical qualities of the steel by taking testpieces from forgings which have been subjected to more or less heavy drawing down. In rolling, the deformations are very much more regular than in forging, and they may be considered as practically uniform, at any rate in the direction of rolling. Lines originally parallel with the axis of rolling remain rectilinear and parallel during the course of deformation. It will suffice to quote one of the many experiments carried out to verify this conclusion. A cylindrical steel bar was bored along its axis, and the resulting hole very accurately filled by a round rod of steel of the same type but containing more manganese. The bar was cut into two portions, which were subsequently transformed into cylinders of half the diameter, either by rolling or by forging; the cylinders were sectionised along the plane of their diameters and the sections etched with iodine. Fig. 4, Plate II., gives photographs of the sections thus obtained. In the forged bar we find the inequalities already described in analogous cases in the preceding paragraph, but in the rolled bar the cylinders have remained perfectly regular and concentric. The same result has been obtained by varying, in different ways, the conditions of the experiment.

It may thus be recognised that the rolling of an ingot into bars introduces no dissymmetry along its axis; test-pieces taken from the same bar at equal distances from the axis may be regarded as having undergone exactly the same deformation. It

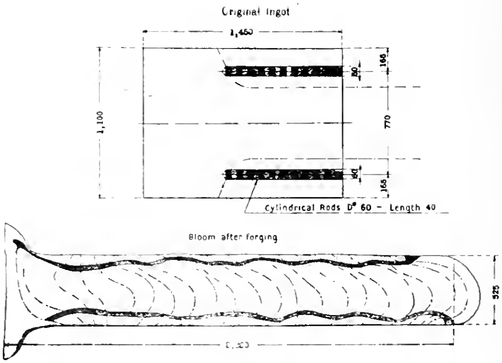



Fig. III.

would, perhaps, be straining matters to extend this conclusion to test-pieces taken at different points in the same transverse section, but there is, on the other hand, a dominant reason to forego comparison of such testpieces owing to the variations in composition and in structure which are inevitable in the transverse sections of any ingot. This can be seen in comparing two bars of different sections by collating the results furnished by test-pieces taken from regions corresponding with the same fractions of the total radius, and therefore with the same region in the mother ingot.

II.

The author will now describe certain experiments

carried out, and, bearing in mind what has already been said, will endeavour to determine the influnee of hot-working on the properties of steel.

Experiment No. 1.—Three identical ingots, of square section with rounded corners (355 × 355 millimetres) were cast simultaneously. The metal employed was a gun steel, made in an acid furnace from very pure materials—that is to say, of the quality which will best serve to obtain satisfactory results in tests from bars cut across (perpendicular to the direction of drawing down). These three ingots, regarded as identical, were rolled after having been heated under exactly the same conditions, and reduced to the dimensions of 225 × 225 millimetres for the first, 165 × 165 millimetres for the second, and 125 × 125 millimetres for the third. The coefficients of working were thus 1.7, 3.2, and 6.1. From each of the resulting blooms test-pieces were taken for tensile tests, for shock bend tests, and for notch tests, with both longitudinal and cross

Plate II.

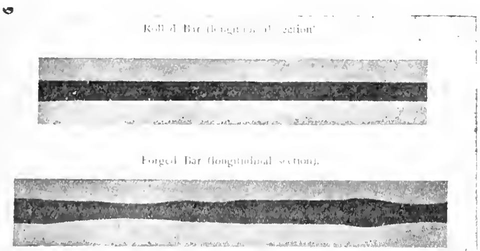
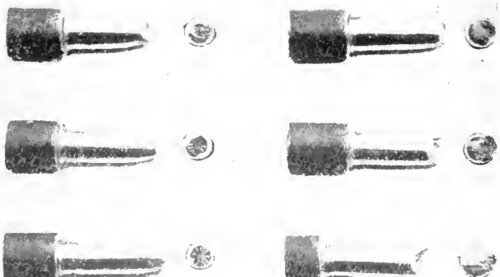



Fig. 1.—It is shown, from above, that rolling has the advantage, over forging, of not introducing any dissymmetry in relation with the axis of the resulting bar.



Figs. IV. and V.

Fig. 5. This photograph shows the fractures, in profile and plan, of six test bars. On the left the bars were taken parallel with the direction of rolling (longitudinally); on the right at right angles to the direction of rolling (transversely). Each pair (horizontally) were taken from the same bloom.

The two upper test pieces correspond with a coefficient of working of 1.7. The fractures are practically alike.

The two lower test pieces correspond with a coefficient of 6.1; the elongations and contractions were 22 and 170 respectively for the longitudinal bar, and 12 and 31 for the transverse bar. The fracture of the longitudinal bar (on the left) is a good fracture of the cup type, with considerable contraction; that of the transverse bar (righ side) is oblique and the contraction is practically nil. In the case of the centre test pieces the mechanical properties are intermediate.

notches. These test-bars were all cut from points taken from the same regions of the ingot both in the longitudinal and transverse directions, and were situated at one-third of the distance between the surface and the axis so as to avoid the influence of segregation and of axial porosites; their axes were thus identical from all points of view, except from that of the "coefficient of working." The bars themselves were slightly different inasmuch as, having the same ultimate dimensions, they comprised portions of the metal of the ingot spread, more or less widely, around the axis. Seeing, however, that this metal only occupied a small portion of the section, these differences can, in the author's opinion, be regarded as negligible.

The test-bars were quenched and annealed under exactly similar conditions (quenched from 850° and annealed at 600° C.), and then subjected to tests. The following results were obtained:

(a) Tensile Tests. The tensile strength of each is practically the same; the elongations increase slightly, in the longitudinal samples, under hot working and decrease notably in the transverse test-bars, and the same thing, only much more markedly, occurs in regard to the reductions in area. It is, however, the variation in reduction of area which alone influences the total elongation; the curves of tensile strength being practi-

| Coefficient of Working | Longitudinal Tests. | | Transverse Tests. | |
|---|---|---|---|---|
| | 1. | 2. | 1. | 2. |
| 1·7 | 6·5 | 7·1 | 5·3 | 5·8 |
| 3·2 | 7·9 | 8·3 | 3·9 | 4·1 |
| 6·1 | 9·9 | 10·1 | 3·5 | 3·5 |

Table D.

cally identical and superimposable, up to the breaking point. The fractures vary naturally with the reductions in area; they are normal even in the transverse bars in the case of the bloom which has undergone little deformation, and take an oblique form in the transverse bars which have been strongly worked. Fig. 5, Plate II., is a photograph of the bars tested.

(b) Impact Bend Tests.—The tests were made on two bars 24 × 9 × 75 millimetres, clamped at one end and subjected to the impact of a 10-kilogramme tup falling from a height of 1 metre.

None of the longitudinal bars could be broken by impact. The transverse bars broke respectively after 29, 27, and 23 blows.

(c) Impact Tests on Notched Bars. — The bars, measuring 10 × 10 × 53.5 millimetres were notched half-way through and tested under the drop test machine. Two bars were tested from each bloom, the notches being given the two rectangular positions possible in the circumstances. The figures given show the work absorbed by rupture, expressed in kilo-

| Coefficient of Working | Longitudinal Tests. | | | Transverse Tests. | | |
|---|---|---|---|---|---|---|
| | Tensile Strength. | Elongation. | Reduction in Area. | Tensile Strength. | Elongation. | Reduction in Area. |
| 1·7 | 91·2 | 20 | 111 | 90·9 | 18 | 76 |
| 3·2 | 91·6 | 20 | 140 | 90·5 | 16 | 67 |
| 6·1 | 90·5 | 22 | 170 | 90·6 | 12 | 31 |

Table E.

grammes and calculated per square centimetre of the section at rupture.

The variations are here much more marked and, most sharply defined. Hot working increases the impact resistance longitudinally and diminishes it greatly in the transverse direction, the more so the greater the amount of deformation. Within the limits of the experiment the average differs but slightly.

Second Experiment.—Instead of taking several different ingots two fragments from the same ingot (the same metal as in the preceding experiment), subjected to different amounts of working, were compared. To begin with and in the first heat the section was reduced from 355 × 355 millimetres to 225 × 225 millimetres (coefficient = 1.7), and, secondly, a piece of the bloom thus obtained was submitted to a second heat and the section reduced to 125 × 125 millimetres (total coefficient = 6.1). The piece from the first bloom, which had not been rolled, was replaced in the reheating furnace at the same time as the second piece, so that it should undergo the same heat treatment. The results agreed completely with those of the preceding experiment.

(a) *Tensile Tests.*

| Coefficient of Working. | Longitudinal Tests. | | | Transverse Tests. | | |
|---|---|---|---|---|---|---|
| | Tensile Strength. | Elongation. | Reduction in Area. | Tensile Strength. | Elongation. | Reduction in Area. |
| 1·7 | 91·6 | 18 | 110 | 92·2 | 13 | 87 |
| 6·1 | 91·3 | 22 | 165 | 92·5 | 14 | 54 |

Table F.

(b) Impact Bend Tests.—The two longitudinal bars did not break; neither did the transverse test-bar, which had been but little worked. The transverse test-bar which has undergone most working broke at the forty-second blow from the tup.

(c) Impact Tests on Notched Bars.

| Coefficient of Working. | Longitudinal Tests. | | Transverse Tests. | |
|---|---|---|---|---|
| | 1. | 2. | 1. | 2. |
| 1·7 | 7·5 | 7·5 | 5·3 | 6·0 |
| 6·1 | 9·3 | 9·5 | 3·5 | 3·2 |

Table G.

Third Experiment. — The preceding experiments were carried out on metal chosen in such a manner as to eliminate, as far as possible, the differences between the test-bars taken, both in regard to the amount of work they had undergone and in regard to its direction. It appeared necessary to try the second experiment over again on a metal of the same grade and of current quality (semi-hard basic steel, as used in the manufacture of shells).

An ingot 355 × 355 millimetres was taken and treated exactly as described above, except that in the heat treatment of the bars annealing was carried out at a higher temperature (650°C.) than in the preceding case, so as to diminish the increase in the tensile strength due to quenching and to get the metal into the condition of minimum brittleness. The results obtained were as follows:—

(a) *Tensile Tests.*

| Coefficient of Working. | Longitudinal Tests. | | | Transverse Tests. | | |
|---|---|---|---|---|---|---|
| | Tensile Strength. | Elongation. | Reduction in Area. | Tensile Strength. | Elongation. | Reduction in Area. |
| 1·7 | 70·1 | 18 | 33 | 70·7 | 11 | 27 |
| 6·1 | 72·7 | 23 | 60·5 | 68·4 | 4 | 8 |

Table H.

(b) Impact Bend Tests.—The two longitudinal bars broke after 17 and 40 blows from the tup respectively. The two transverse bars broke after the eighth blow.

(c) Notched Bar Tests.

| Coefficient of Working. | Longitudinal Tests. | Transverse Tests. |
|---|---|---|
| 1·7 | 3·50 | 2·00 |
| 6·1 | 9·10 | 1·50 |

Table I.

The experiments which have just been described, carried out under conditions as clearly defined as possible, and with the object of ascertaining the influence of hot-working, confirm and emphasise a series of results of a qualitative nature obtained earlier.[1] If it be that no evidence to the contrary was observed, it may be regarded as an established fact that the hot-working of steel does not appreciably affect the tensile strength, or the corresponding elongation, either longitudinally or transversely. On the other hand, hot-working improves the reduction of area, the resistance to impact, and the impact resistance longitudinally, and considerably diminshes these values transversely.

The extent of the variations depends on the nature of the metals; it is much more marked in metals of mediocre purity, such as that employed in the third experiment (phosphorus 0.05 and sulphur 0.06 per cent.), than in very pure and dense metals, such as those employed in the first experiments (phosphorus 0.02 and sulphur 0.015 per cent.). The difference will be still more marked in still more unsound and impure metals such as are often employed, and in which the elongations and the impact transversely become practically nil once the drawing out reaches a given value.

The favourable influence attributed to hot-working rests therefore solely on the fact that in the bulk of the cases only the results of longitudinal tests have been taken into consideration, and that the conclusions arrived at have been duly extended to certain products, such as gun steel, for which, nevertheless, transverse tests are required. This conclusion has been made the subject of different check experiments, amongst which it will be sufficient to quote the following:

From the same cast of semi-hard open-hearth steel, obtained in an acid furnace by melting very pure materials, there were prepared, on the one hand, an ingot of 800 kilogrammes and 8.6 square decimetres in average section, and, on the other hand, an ingot of

[1] See, in particular, the bearing of the results obtained on pieces of the same shape obtained by starting with different ingots after drawing down from 1.27 to 11.88, and given in "Conditions et Essais de Réception des Métaux." Paris: Dunot & Pinat, 1917.

10,000 kilogrammes and 61 square decimetres section. These ingots were used to prepare, by forging, the oval-shaped cylindrical pieces shown in Fig. 6, in which there has been superimposed in each case the outline of the ingot (in broken line) and the outline of the forging made therefrom (in unbroken line). The reduction in section was thus but slight in the case of the small ingot and exceedingly high in the large ingot. The resulting pieces were, after forging, subjected simultaneously, in the same furnace, to a heat-

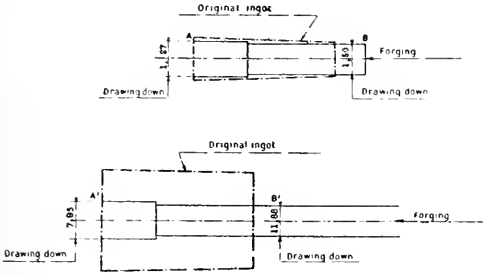



Fig. VI.

treatment that comprised a quenching in water from 830°C. and an annealing at about 600°. Test-pieces for tensile tests and impact bend tests were subsequently taken from both ends, and at right angles to the direction of forging. The tests yielded the results summarised in the table below:

| Point from which Test-pieces were taken. | Coefficient of Working | Tensile Tests on Bars measuring 13 × 8 mm. in Diameter taken transversely | | | Impact Tests with a Free-falling Tup upon Bars measuring 24 × 9 mm in Diameter taken transversely. | |
|---|---|---|---|---|---|---|
| | | Thickness. | Tensile Strength. | | Number of Blows borne without Breaking. | Bending Angle. |
| A | 1·27 | 50·1 | 68·7 | 15 | 26 | 70° |
| | | 50·2 | 69·0 | 15 | 26 | 71° |
| B | 1·50 | 49·5 | 69·7 | 20 | 26 | 74° |
| | | 50·1 | 70·7 | 18 | Broke at 23rd blow | 82° |
| A' | 7·95 | 50·8 | 67·4 | 10 | ,, 16th ,, | 105° |
| | | 49·5 | 66·1 | 9 | ,, 18th ,, | 107° |
| B' | 11·88 | 52·1 | 68·1 | 12 | ,, 12th ,, | 132° |
| | | 51·5 | 68·1 | 12 | ,, 16th ,, | [illegible] |

Table J.

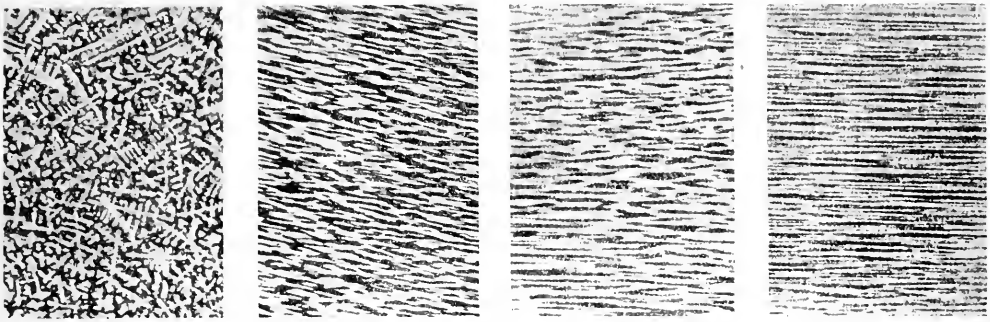
It will be seen that the results obtained with bars from the large ingot are distinctly inferior to those obtained with bars from the smal ingot. It would therefore appear to be a certainty that, in regard to pieces tested transversely, a mistake is made every time an attempt is made to improve the quality by increasing the amount by which the metal is drawn down. In regard to all other metal parts it is necessary, in order to ascertain in what instances hot-working may be of use, to appreciate the relative amounts of deformation undergone longitudinally, transversely, and at various obliquities. This constitutes a problem respecting the strength of metals which is completely beyond the scope of this paper, and to the importance of which reference can alone be made here. It is, however, probable that the instances in which hot-workings is injurious are fairly numerous.

Results relative to the influence of hot-working on the properties of steel appear to be pretty easily ascertainable,taking into account the new data as to the heterogeneity of steels which the new cupric reagents recently employed by Drs. Rosenhain and Stead and Mr. Le Chatelier enable us to obtain. Plate III. is a reproduction of preparations obtained by this process, and shows that the dendrites formed during the solidification of the steel undergo deformation during rolling, but do not in any way tend to disappear. Subsequent heat treatments do not modify this structure. There is thus found, in juxtaposition in the steel, two series of elements corresponding with two different compositions [the dendrites of the initial solidifeation and the filling (ciment de remplissage)], and the mechanical properties of which differ. Generally speaking, the filling which has solidified latest will contain a higher proportion of impurities and will be less ductile then other portions of the metal. In molten steel the two elements are distributed more or less uniformly, and, except in certain portions of the ingot, do not present any marked orientation; although it must not be forgotten that the ingot is far from being isotropic. In any case rolling will produce very pronounced heterotropy, which, according to the circumstances, may increase or hinder that already pre-existing in the ingot, but which will always tend completely to predominate over it once deformation has reached a certain amount. Rolled steels will therefore always present a structure composed by the juxtaposition of elements practically rectilinear and parallel with the direction of rolling, and the transverse dimensions of which will be the more reduced, according as, other things equal, the coefficient of working has been greater.

It will easily be conceived that the distribution of the alternating elements along the axis of a tensile test-piece or in the notch of an impact test-piece varies with the direction of the bar in relation to the bloom and with the amount of drawing-down undergone by this bloom, and that these differences in distribution will strongly induce variations in the mechanical properties. Without attempting to follow in detail the application of the foregoing to an actual instance, it will be seen that, the relative proportions of the two elements being fixed and determined by the nature of the steel, the differences between test-pieces may be characterised by the length of the heterogeneous elements juxtaposed along the length of an axis. It may be conceived likewise that the tensile strength must be determined by the nature of the elements, and not by their dimensions, which are, therefore, without marked influence on the breaking stress, and that this influence on the general deformations must also be but slight. In highly localised deformations, however, such as those which precede breaking, the dimension of the element which undergoes this deformation plays a highly important part, inasmuch as the breaking occurs once this element has reached its limit of deformation. This limit will be the sooner reached the smaller the dimension of the element, other things that is, equal and that, consequently, the metal will have been the more drawn out for a given orientation of the test-piece, or that for a given drawing down the bar in question shares more closely the direction of the elongated elements. These two con-

Plate III.

Fig. 7.—Deformation of the dendrites of the original ingot by successive rollings.



(A) Ingot: Natural state.

(B) First rolling (elongation 5/1).

(C) Second rolling (elongation 30/1).

(D) Third rolling (elongation 150/1).

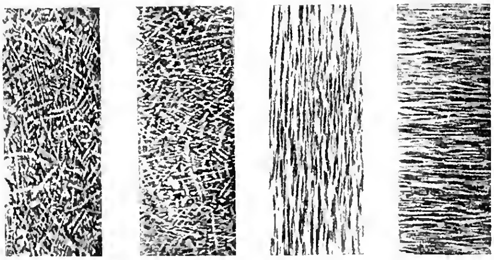
ditions will lead to a decrease in the contraction of area and in the angle of impact-bend prior to breaking, in notched bars, and hence to a diminution in the work of rupture they can withstand.

In Plate IV. there are reproduced (enlarged to double natural size) the structures observed in the impact test-bars tested in the second experiment described in Part I.

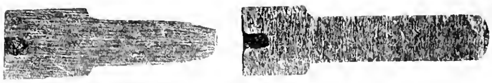
The photographs A and B correspond with the longitudinal and transverse bars respectively taken after drawing down to 1.7. It will be seen that the dendrites of the first solidification have been but little deformed, and that, as a result, their directions differ but little, and it may be foreseen that the work of rupture attained will differ but little betwen them. The actual figures obtained were 7.5 (longitudinally), and 6 (transversely). On the other hand, after drawing down to 6.1 the orientation is very clearly marked, as shown by the photographs C (longitudinal test-bar) and D (transverse test-bar). The differences in impact figures observed correspond with these differences in structure, namely, 9.5 for the longitudinal bars and only 3.5 for the transverse bars. In Fig. 9, Plate IV., is shown the structure of the two tensile test-pieces corresponding with a coefficient of working of 6.1, tested in the first experiment of Part I., and the outer appearances of which are shown in Fig. 5, Plate II.

From what has been said, it will be possible to appreciate—at any rate qualitatively—the influence of working, at any point, within a piece, from the relation between the dimensions and direction of the less resistant (or more particularly the more ductile) structures, and the test-pieces to be employed in ascertaining the mechanical properties. The nature of these structures, their dimensions, and their directions will depend upon the conditions of casting of the original ingot and on the different deformations they may have undergone in the course of working. It will be seen from this, even better than from what has been said in the first part of this paper, how illusory it is to attempt to deduce the influence of working from a simple formula based solely on the initial and final outward shapes of a forging. It will, in particular, be understood how a number of successive forgings which restore a block of metal to its original dimensions after having subjected it to different deformations (de

Plate IV.—Figs 8 and 9.



(A) (B) (C) (D)



(A) (B)

Fig. 8.—These photographs show the appearances obtained on etching the notch surfaces of one of the pieces from four different notched bars, with cupric reagent.

The test piece A was clt longitudinally, and the test piece B transversely from the same billet, which had been drawn down 1.7. The dendrites of the original solidification are but little deformed, and the impact values obtained are in the neighbourhood of one another (7.5 for A, and 6.0 for B.) The test piece C (longitudinal) and D (transverse) were taken from the same billet which had been drawn down 6.1. The orientations due to rolling are very marked, and the impact values (9.5 for C and 3.5 for D) differ greatly.

Fig. 9.—These photographs show the results of etching sections across the diameters of two of the test bars shown in Fig. 5, with cupric reagent. This etching has brought out the structure, which corresponds with the type of fracture.

(A) Longitudinal bar. Normal fractture and contraction.

(B) Transverse bar. Oblique fracture without contraction.

Plate V.—Fig. 10.

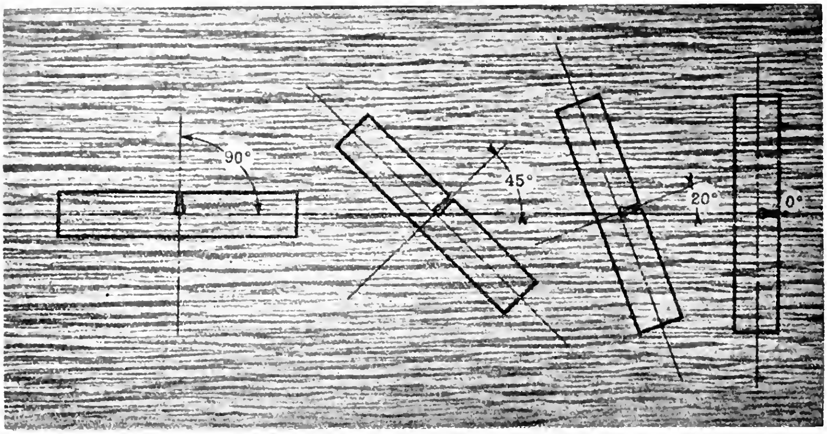



Fig. 10.—This figure shows the method by which notched-bar test bars were taken, in a rolled bar, to show the marked influence of the direction on the impact value. The test piece, the notch of which is perpendicular with the direction of rolling, gave an impact value of 13.50; the test piece, the notch of which is parallel with the direction of rolling, gave an impact value ten times lower, namely 1.30

formations which will vanish in all the ordinary formulae relating to working) may have profoundly affected the mechanical properties, or, to say the least of it, the relative values of these properties in different directions. Such conditions intervene even in the simplest forging operations, when the method of working involves intermediate shapings of great local variety, which is nearly always the case.

The considerable influence of the orientation of the structures is well brought out in the following experiment:

A piece of the semi-hard ingot employed in the third experiment in Part I, was reduced, by rolling, to a section of 75 × 75 millimetres, the coefficient of working being thus equal to 13. The section thus produced did not allow of the different types of test-pieces being taken both longitudinally and transversely. Only notched bar test-pieces were therefore taken, but, in lieu of longitudinal and transverse bars, two others were taken at angles of 70° and 45° with the axis, all taken from the same longitudinal cut. Plate V. shows the lay of these bars: there has been reproduced, at a magnification of four times, the structure of the metal, as shown by etching with the cupric re-agent, so as to bring out the orientation of the fracture surfaces in relation to the structures of the metal.

The impact tests, carried out after quenching and annealing the bars, gave the following results:

| No. of Bar. | Angle of Notch with Direction of Rolling. | Work Absorbed on Rupture. |
|---|---|---|
| 1 | 0 | 1.30 |
| 2 | 20 | 1.50 |
| 3 | 45 | 3.40 |
| 4 | 90° | 13.50 |

Table K.

## Conclusions.

From the collection of facts and considerations contained in this paper it may be concluded that the amount of the deformation undergone at a high temperature by a block of steel affects the properties of the metal according to a complex law which involves the initial state of the ingot and all the subsequent deformations, and the chief characteristic of which is to create strongly marked heterogeneity. There is found a variation in the properties not only of degree, but of nature as well, according as the direction of the test-bars employed varies in relation to the piece whence they are derived. The total effect is far from being in the nature of a general improvement, as would appear to be looked for whenever, in specifications, a minimum amount of working is prescribed. It would appear, on the contrary, that the result is more injurious than useful, and that, consequently, the specification of a maximum deformation would be more logical. It is impossible to fix a general rule. For pieces working under transverse stresses, such as guns, drawing down lengthwise has undoubtedly an injurious effect, at any rate in mechanical tests required in inspection, and it would be better to reduce it as little as possible. For steel parts of more complex shape the problem differs in each specific case, and it would appear that the only guidance is by studying the conditions beforehand. The designer, who knows how he wants the part he has designed worked, should construe his ideas into deciding the localities from which test-pieces should be taken corresponding with predetermined conditions; these test-pieces should be taken in different directions if these be the conditions under which the material will be employed, and the metallurgist, in order to meet with these fixed conditions, should in each case select the type of ingot to be employed and the nature of the deformations to which it is to be subjected.

# The Principles of Open-Hearth Furnace Design

By CHAS. H. F. BAGLEY (Stockton-on-Tees.)
English Iron and Steel Institute, Sept., 1918.

In view of the keen interest now being taken in the subject of open-hearth furnace work and design, with the object of raising British practice up to or above the standards of continental and American practice, the author has thought it opportune to submit a paper in which the subject can be more fully discussed than was possible in the form of reply to the recent Circular Questionnaire issued by the special Committee of the Iron and Steel Institute. The subject may conveniently be resolved into two distinct branches, viz., Metallurgy and Design, the former being chiefly concerned with obtaining the best results from a given furnace, and the latter with a best design for a new furnace (or improvements in existing furnaces). In both directions there seems to be room for some improvement in British practice as a whole. In this paper he endeavours to discuss the subject of design, both from the scientific and the practical points of view, in the light of some fifteen years' varied experience in England, Germany and the United States. For the sake of brevity, opinions are definitely expressed, but he hopes it will be understood throughout that they are but the expression of personal views.

### General Requirements.

In order to melt steel at all, the first requirement is an exceedingly high temperature, and it can almost be said that it is hardly possible to attain too high a flame temperature, provided the flame is under control and not allowed to impinge direct on the brickwork. As in the blast-furnace, so in the steel furnace, output and efficiency are functions of the average temperature attainable, rather than of the heat units generated; for temperature is the factor which determines the efficiency of utilisation of such heat units. The chief object of regenerating gas and air is thus not so much the recovery and return to the hearth of a proportion of the waste heat units, but rather to enable a higher flame temperature to be reached, by means of highly superheating both gas and air before bringing them into contact. It is important, therefore, that the highest possible temperatures should be reached in the checker chambers, so that they may be realized in both gas and air on reversing; and also that the checker work should be deep enough to allow a high average temperature to be maintained throughout each reversal. Consideration of the subject of theoretical flame temperatures shows that to realise the maximum it is important to provide not only a rich gas, but a dry gas and air (very important points, but outside the subject of furnace design), together with the minimum excess of air for complete combustion, and the maximum initial temperature on each. It is important that the initial temperatures of gas and air should be approximately equal throughout; for the fact of one being higher than the other rather implies that the other is less than it might have been, and the resulting flame temperature correspondingly lower. In designing the furnace, these points should always be taken into account; and the heating surface, and supply of heat to gas and air chambers respectively, should be arranged accordingly.

Though these points may appear to be minor matters, it should be remembered that their effect is cumulative, for a higher flame temperature results in a shorter, but more intense flame, which allows more gas to be carried, with a greater development of heat in the furnace and a higher temperature of outgoing gases, and this, in turn, results in hotter checkers and a higher temperature of gas and air on reversal, and further increase of flame temperature, etc., till the furnace becomes considerably hotter—and the most effective way of keeping the heat down is by frequent charging and tapping. The author worked for some months on such a furnace in Germany in 1904—carrying out the so-called "Martin process"—with 75 per cent. of scrap, for spring, tire, and axle steels, and tapping 12-ton heats every $4\frac{1}{4}$ hours as regularly as clockwork, and all hand-charged, too.

The average make was 36 heats (436 tons) per week start charging Sunday 9 p.m.—last tap before Sunday 6 a.m.—12-hour shifts—average life 390.6 charges — repairs cost 2.03 shillings (bricks and labour)—wages cost 3.80 shillings—coal consumption 25.54 per cent.—ingot yield 95.34 per cent.); while some new 50-ton furnaces, machine-charged, at the neighbouring works of Thyssen at Mulheim, making plate steel by the same process, were getting 18 to 20 charges (900 to 1,000 tons) weekly, and a life of 460 to 520 charges. A keen furnace is especially important for such practice, so that the charge can be melted quickly (without risk of losing the carbon) and the proportion of pig iron and lime used (and slag made) reduced accordingly; thereby also reducing the period of boiling for tapping, and speeding up the whole process. The effect of moisture on the flame temperature of the gas should be thoroughly appreciated, and the amount present kept down by all simple and reasonable means —i.e., producer coal should be dry and protected from the weather, and excess of steam in blast (passing through undecomposed) should be avoided. In the checker chambers it is liable to dissociate into hydrogen and free oxygen, which at once attacks hydrocarbon gases and CO present, so that partial combustion takes place in the chambers at the expense of the quality of gas arriving at the furnace.

### Open-Hearth Furnace Design.

(Pressure and Temperature Diagrams.)

Before proceeding to the subject of combustion and volumes, it is well to consider the conditions of pressure existing in the furnace, flues, and valves, and the forces behind the gas and air, and in the chimney.

The incoming gas will usually have behind it an initial pressure of 1 to 2 inches (water gauge, but this is reduced by the regulating valve to suit the requirements of the furnace; while behind the incoming air there is only the difference in density between two columns of air of atmospheric and regenerated temperatures respectively, and of height equal to that between the bottom of the checker chambers and the level of the air port. The effective height of the chimney should be measured from the level of the

ports, and its pull considered as being exerted at the face of the ports. The pressure in the body of the furnace must necessarily be atmospheric and approximately balanced; for the velocity of gases under the slightest suction—or pressure—is such that if not, there must be an enormous inrush of cold air or an equally large outburst of flame at every door and crevice. The incoming gas and air must, therefore, be considered as being delivered under slight pressure through large orifices into an open space, combustion taking place under constant (atmospheric) pressure, and the flame and waste gases travelling freely down the furnace until they come within the influence of the chimney draught near the face of the ports. Thereafter the waste gases are under a slight negative pressure, and will expand in volume accordingly; but throughout the differences in pressure vary so slightly (rarely more than 5 mm. Hg., or 0.66 per cent.) from the atmosphere that their effect on volumes is almost negligible, and especially so when compared with the variations due to differences of temperature at various points in the circuit.

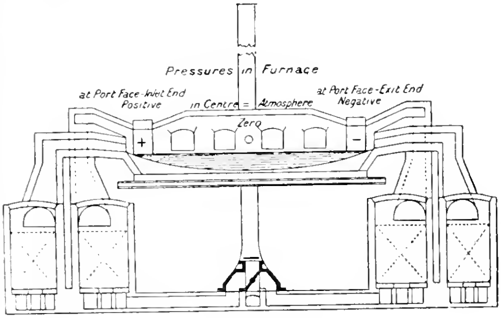



Fig. 1.—Pressure Diagrams, &c.

*Supply Conditions.*

Gas pressure in main = say, 2 inches w.g.
Air pressure at valve = atmosphere.
Draught at chimney base = say, $1\frac{1}{4}$ inch.

*Gas Pressure* { in flues = supply pressure, subject to valve regulation.
at port = ,, ,, plus pressure, equivalent of height.

*Air Pressure* { in flues = atmosphere, subject to valve regulation.
at ports = ,, plus pressure, equivalent of height.

*Suction* { in flues = chimney draught, subject to damper.
at ports = ,, ,, less pressure, equivalent of height.

Thus all questions of areas are mainly dependent on temperatures rather than on pressures at different positions.

The diagram (Fig. 1) clearly illustrates the points. It should always be remembered that the amount of gas admitted to the furnace is, and must be, regulated at the inlet valve to suit the requirements of the furnace; and the air should be regulated to suit the gas supply. In practice, however, the usual difficulty is to get sufficient air supply to consume the gas available, the gas being under a positive pressure. Hence the prevailing custom is to open the air valve to its full and to regulate solely on the gas valve. Deep checkers are, therefore, necessary not only for high initial temperatures, but also to ensure an ample supply of hot air to the furnace, without which full use cannot be made of the gas available. The chimney height should be increased accordingly.

The actual pressure at different points can hardly be foretold under such conditions; but it is often useful to have a pressure diagram—taken when the furnace is in good condition and working well—as a basis for comparison with conditions prevailing towards the end of its life. Without a standard for comparison, such diagrams are of little value! and the author prefers a diagram of temperatures at the corresponding positions—always taken, of course, at the same stage of the process (say just before tapping and just after reversing).

Pressures should be taken on the incoming end: (1) At the valves or in the flues before entering the checker chambers; (2) in the slag pockets or checker chambers after regeneration; (3) at the top of uptakes (virtually in the ports); and at the corresponding positions on the outgoing end—care being taken to note the difference between positive and negative pressures.

The initial pressure in the gas main, and the maximum draught at the chimney base, should also be noted; the furnace should then be reversed and the readings repeated.

With the temperature diagrams there is no question of positive and negative results. The readings should be taken in the same positions, but care should be taken that the furnace conditions are the same, and that the furnace has been working the same length of time on each end. The relative volume of air, gas, and waste products passing at any point is mainly affected by their temperature variations (which are considerably, rather than by their pressure variations (which are comparatively small), and their velocities are proportional to the volume passing divided by the sectional area at that point, subject, of course, to frictional losses. Given their initial volumes and temperatures, and the subsequent temperatures at different positions, it is possible to calculate the areas so that the velocities will be approximately constant throughout. The volumes entering are, however, subject to control at the inlet valves, and the volumes delivered into the combustion chamber are limited by the area of the discharging orifices (or ports). Between these two points, sectional areas may be anything desired, provided they are not less than the ports, and may, therefore, be determined by other considerations. So also as regards the outgoing end—the flow of waste gases is subject to control by damper in the chimney flues, and to the inlet area at the ports; and the sectional area at any point between may be anything desired, provided not so small as to check the even flow between these two points. The gas and air port areas (and chimney flue areas) must be taken together as regards the total volume of waste gases to be passed; but the question of proportions to be taken by each will be determined by other considerations. It may be noted here that when these proportions are decided, they can be permanently and automatically secured—without the aid of dampers on every chimney flue (which would be extremely difficult to regulate accurately)—by simply proportioning the chimney flues, behind the valves, to the volumes of waste gases it is desired to draw through gas and air chambers respectively. The author has always considered this one of the most important and least considered points in the whole design. The usual practice is to "make them big enough," regardless of relative volumes or other reason—with various results in the checker work and on the initial temperatures of gas and air—all resulting in loss of flame temperature and efficiency of furnace.

### Furnace Details. (Port Ends).

The respective merits of different types of port ends are much disputed questions, particularly as between the two standard types, (1) the solid block with two air ports (Fig. 2a), and (2) the open block with a single overhead air port (Fig. 2b): and it seems to remain purely a matter of opinion and of correct detail, to the absence of which so many failures are attributable. Type (2) is generally regarded as the keener and faster working design, and allows a short length of combustion space before the hearth proper is reached, and, of course, removes the block so much further back on the outgoing end, thus reducing the chance of "burning" it. On the other hand, it is the weaker structure and requires more careful designing or the gas port is liable to lose its shape and throw the live gas on to the linings. Its natural tendency is to spread the flame and keep it down (whereas the opposite is the case with the three-port type), and a wider furnace is desirable for this type. The three-port type, though slower-working and allowing no preliminary combustion space, is said to stand up better, though it has to stand the direct heat of the outgoing gases, and is liable to get "burnt" unless the gas supply is closely regulated. No great care is needed in design or building; there is less chance of burning the side walls (though more of the roof), and there is no brickwork subject to heat on both sides without cooling surface, as in the case of the arch between gas and air ports in type (2) On the whole, there seems little to choose, though personally the author prefers the keener furnace. These remarks apply equally to tilting-furnaces, but the necessity of movable port ends rather complicates the matter. In type (2) the joint between furnace and port ends is made at the face of the block, the furnace end being open, and the ports built in a single solid block outside—which, of course, is a great weight. In the three-port type the joints are made in the ports themselves, the block face remaining in the furnace proper. By this arrangement it is possible to build the movable ports in three separate sections, none of them very heavy, so that they can be lifted and taken away by the overhead crane and a spare put back in their place. The repairs can then be done later, when cold, and the week-end repairs are very much reduced.

By careful design it might be possible to build a block of type (2) in a single piece so light that it could be handled and changed by the overhead crane as the individual ports of type (1) are—which would greatly simplify matters and yield the advantages of both.

One of the advantages of a tilting furnace is the facility of getting at the ports for repairs at the week-end.

### Combustion of Producer Gas.

The combustion of 100 M³, assumed dry and neglecting tarry vapours, of analysis as under and at 0° C. by 760 millimetres pressure, is as follows:

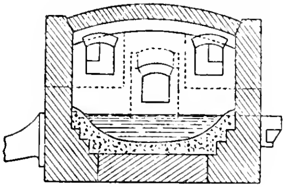
| By Volume. Per Cent. | | | | By Weight. | | | |
|---|---|---|---|---|---|---|---|
| $H_2$ | 8·0 | = | 0·72 kg. requires oxygen | 5·6 kg. | to form | 6·3 kg. | $H_2O$ |
| $CH_4$ | 5·0 | = | 3·60 „ „ | {7·2 „ | „ | 8·1 „ | „ |
| | | | | {7·2 „ | „ | 9·0 „ | $CO_2$ |
| CO | 25·0 | = | 31·50 „ „ | 17·9 „ | „ | 49·4 „ | „ |
| $CO_2$ | 5·0 | = | 9·90 „ „ | ... „ | „ | 9·9 „ | „ |
| $N_2$ | 57·0 | = | 72·00 „ „ | ... „ | „ | 72·0 „ | $N_2$ |
| | 100·0 | = | 116·70 „ „ | 37·9 | | 155·6 „ | products |

Table A.

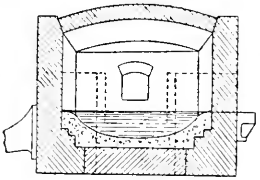
To this 37.9 kilogrammes oxygen may be added some 25 per cent. excess to ensure complete combustion, bringing up the total oxygen required to 47.4 kilogrammes. This represents 205 kilogrammes of air—introducing 157.6 kilogrammes of nitrogen — which, together with the excess oxygen, must be added to the products as above, making the result as f[illegible]lows:—

| | By Weight. | | Per Cent. | | By Volume. | | Per Cent. |
|---|---|---|---|---|---|---|---|
| $CO_2$ | 69·2 kg. | = | 21·5 | or | 35·0 M³ | = | 14·5 |
| $H_2O$ | 14·4 „ | = | [illegible]·5 | or | [illegible] „ | = | 7·[illegible] |
| [illegible] | 228·6 „ | = | 71·1 | or | 182·[illegible] „ | = | 7[illegible] |
| [illegible] | 9·5 „ | = | 2·9 | or | 6·[illegible] „ | = | [illegible] |
| | [illegible] „ | = | 100·0 | or | [illegible] „ | = | [illegible] |

Table B.



*Type I.*—3 Port Design with Air Cooling.



*Type II.*—Overhead Air Port Design with Air Cooling.

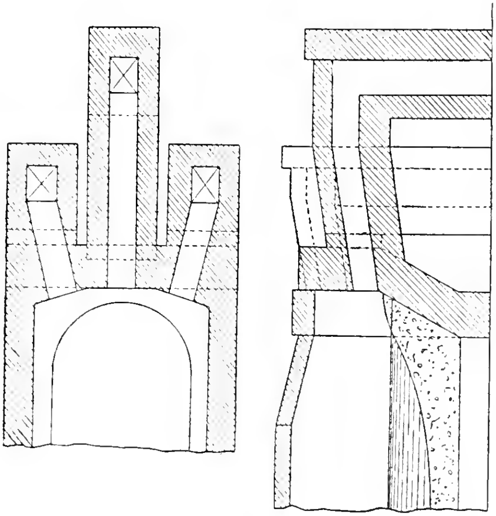


Fig. 2a.

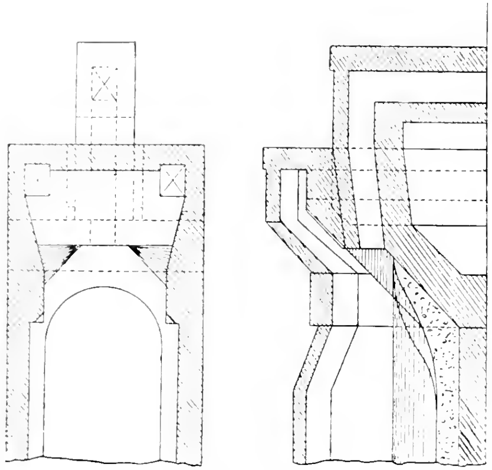


FIG. 2B.

Thus 100 $M^3$ gas (=116.7 kilogrammes) requires 159 $M^3$ air (=205 kilogrammes) to form 242 $M^3$ (=323 kilogrammes) of products—all volumes under standard conditions (0° C. × 760 millimetres).

In practice the conditions are different, and may be assumed approximately as under:

| | | |
|---|---|---|
| *Air.* | At inlet valve | 15° C. by 760 millimetres |
| | After regeneration | 1250° C. ,, 760 ,, |
| *Gas.* | At inlet valve | 500° C. ,, 765 ,, |
| | After regeneration | 1250° C. ,, 765 ,, |
| *Waste Products.* | At port face, say | 1500° C. ,, 750 ,, |
| | In chimney flues | 600° C. ,, 755 ,, |
| 100 *M³ of gas* (0° C. by 760 millimetres) then becomes | | 208 M³ entering at valve |
| | | 555 ,, ,, through gas port |
| 159 *M³ of Air* (0° C. by 760 millimetres) | ,, | 168 ,, ,, at valve |
| | | 887 ,, ,, through air port |
| 242 *M³ Waste Products* | ,, | 570 ,, going out through ports |
| | | 778 ,, passing through chimney flues |

Table C.

N.B.—It is interesting to note the total volumes entering and leaving the combustion chamber through the ports, viz., 1442 $M^3$ entering and 1570 $M^3$ passing out.

Ratio of Air to Gas Passages.—So far as supply to the furnace is concerned, and subject to regulation by the valves, the intake areas, flues, etc., may be in the ratio of 168/208, or 0.80 air to 1.00 of gas, and the checker chambers, uptakes, and ports, in the ratio of 887/555, or 1.60 air to 1.00 of gas.

It is, however, more important to arrange for the proper distribution of heat between the checker chambers in such proportion as to maintain an equal temperature on both gas and air when the furnace is reversed. This is dependent on the amount of heat to be imparted to gas and air respectively—which thus takes account of their initial temperatures and relative weights—neglecting differences in specific heats. These weights were found to be 116.7 kilogrammes of gas to 205 kilogrammes of air, entering at initial temperatures of 300° and 15° C. respectively; and both are to be raised to 1250° C. by the regenerators. The heat units absorbed in so doing will therefore be in the ratio of 205 (1250—15)=254,000 by air, to 116.7 (1250—300)=110,800 by gas, i.e., in the ratio of 2.30 by air to 1.00 by gas, and the volumes of waste gases passed through air and gas chambers respectively should be in the like ratio—2.30 to 1.00.

To effect this distribution with the same chimney draught in the flues and at the face of either port, the areas of air to gas passages, ports and flues, must be in the same proportion (see Fig. 3), which differs considerably from that required for the incoming gas and air. There are thus two conflicting conditions as regards ratio of port and flue areas, of which the proper distribution of the waste heat is more important; for the incoming volumes can be controlled at the valves. Areas should be fixed accordingly, and the proportion maintained throughout to ensure the even flow of waste gases throughout. The author considers it important to aim at an even flow of gases, and to avoid abrupt changes of velocity as far as possible. It was previously pointed out that sectional areas between ports and flues may be anything desired; but the only place where he considers it desirable to alter this proportion is in the width of the checker chambers, by manipulation of the checker work, where the ratio may be halved to advantage as regards the general design of the furnace, without affecting the balance in any other way. Variations from the data and assumptions, gas analysis, excess of air, moisture, temperatures, and pressures, etc., will affect this ratio to some extent, but it will usually remain between 2.00 and 2.50 to 1.00.

N.B.—The gases arising from the oxidation of carbon in the charge have not been taken into account, as they will rarely exceed 1 per cent. of the total volume of waste gases passing out at say 1500° C. The effect of poor gas is to decrease the ratio of air to gas passages, that of richer gas or excess air, to increase it.

## Open-Hearth Furnace Design.

In designing an actual furnace there are two leading dimensions required as a basis, viz., gas-port area and hearth area per ton of steel capacity, from which the rest may then be calculated. These data are best taken from practical experience with successful furnaces, but with due regard to other working conditions; for practice and circumstances are very variable in both respects.

**Hearth Area.**—In England a hearth area of 5 to 6 square feet per ton is usually allowed for acid furnaces, and 6 to 8 square feet per ton for basic (fixed) furnaces. Continental and American furnaces often have a larger allowance than this and a shallower bath accordingly (especially in the case of the smaller furnaces) and would be made to hold a larger charge, and rated at a higher capacity in this country. Which is the better practice is purely a matter of opinion, largely influenced at home by the factor of wages rates. In any case, the author prefers the English practice of charging as much as the furnace can comfortably hold, if the maximum output is required, but the point should not be overlooked in making comparisons with lower-rated foreign furnaces. Large tilting-furnaces, working the Talbot process, etc., are,

of course, much deeper than fixed furnaces of otherwise similar dimensions, and may hold nearly double the weight of steel accordingly; so that output comparisons on the basis of nominal capacities are altogether misleading, independent of differences in the practice followed and raw materials employed. The only proper basis of comparison of different furnaces on similar practice seems to be their respective outputs per unit of hearth area.

**Gas-Port Area.**—Practice in this respect is very variable, but an allowance of 4 square inches per ton for acid furnaces and 5 square inches for basic furnaces is usually satisfactory. This factor is really proportional to the hearth area, independent of its depth, and is preferably stated in square inches per unit of hearth area—i.e., for acid and basic fixed furnaces, 0.70—0.80 square inches per square foot of hearth. Personally the author prefers larger areas both for gas and air ports—subject to proper control at valves—and, of course, in due proportion to each other.

For a fixed 100-ton basic open-hearth furnace, on these lines (see Fig. 5), the leading dimensions are:

*Hearth.* At 7 square feet per ton = 700 square feet = 50 ft. 0 ins. × 14 ft. 0 ins. } or equal.
= 46 ft. 8 ins. × 15 ft. 0 ins. }

*Gas Ports.* At 0·80 sq. in. per ft. hearth = 560 sq. in. = 24 ins. × 24 ins., or equal.

*Air Ports.* At 2·25 times gas ports = 1260 square inches = 1 overhead type 10 ft. 6 ins. 10 ins./15 ins.; or 2 ordinary ports 25 ins. × 25 ins. each., or equal.

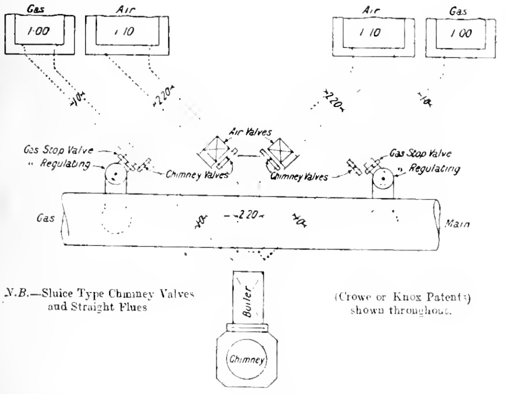



Fig. 3.—Flue and Valve Diagram.

**Uptakes.**—Uptakes may be considerably larger than their port areas, to minimise friction and wear of brickwork, etc., but should remain in correct proportion to each other, as a check on the ratio of port areas.

Table E.

Gas uptakes say 720 sq. ins. = 24 ins. × 30 ins. each, or equal.

Air uptakes say 1620 sq. ins. = 27 ins. × 30 ins. each, or equal.

**Slag Pockets and Bridge Arches.**—To suit structural requirements and to connect smoothly with checker chambers; areas to be well in excess of uptake areas; slag pockets faced with false walls, and half filled with perished dolomite or other suitable material, and should not be too deep, if the slag is to be tapped out molten.

**Checker Chambers.**—Depth of checkerwook 15 feet 0 inches if possible; the top course to be 2 feet 0 inches or so below the bridge for protection and for even diffusion of gases. To provide ample heating surface and reduce the velocity and friction of gases, and to allow for gradual "silting up," the horizontal area of the open spaces should be at least eight or ten times the port areas, and in proportion as before. The length of gas and air chambers being equal, their widths will be in the like proportion (1.00|2.25), which, however, makes rather an awkward design, and I therefore prefer to employ different types of checker work in the two chambers and to adjust their relative widths accordingly. This may be done by using 6 inch by 6 inch open flue type checkerwork in the air chambers, and 6 inch by 3 inch open flue or 6 inch by 6 inch single checked brickwork in the gas (Fig. 4); the width of the gas chamber being doubled to keep the total passage areas in proportion. In the 6 inch by 6 inch open flue type—plan view—the open spaces are four-ninths, and the bricks five-ninths of the total area; whereas in the 6 inch by 3 inch open flue or 6 inch single checked types the spaces amount to only two-ninths and the bricks to seven-ninths of the total area.

The gas-port area was taken at 560 square inches and the air port at 1260 square inches, which, multiplied by 8, gives 31.1 square feet and 70.0 square feet of spaces required in gas and air checkerwork respectively. The gas chamber area will therefore be:

Table F.

For 6 ins. × 6 ins. checker work, $\frac{9}{4} \times 31.1 = 70$ sq. ft. = 14 ft. 0 ins. long × 5 ft. 0 ins. wide, or equal.

For 6 ins. × 3 ins. checker work, $\frac{9}{2} \times 31.1 = 140$ sq. ft. = 14 ft. 0 ins. long × 10 ft. 0 ins. wide, or equal.

and the air-chamber area (with 6 × 6 checkerwork:

Table G.

$\frac{9}{4} \times 70 = 158$ sq. ins. = 14 ft. 0 ins. long × 11 ft. 3 ins. wide, or equal.

The thickness of any false facing walls or solid partitions to be added to above sizes.

It is possible, though unusual, for the checker chambers to be too large, and the author has known

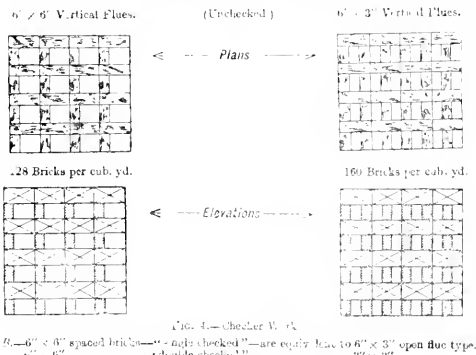



Fig. 4.—Checker Work

N.B.—6" × 6" spaced bricks—"single checked"—are equivalent to 6" × 3" open flue type.
6" × 6" " " —"double checked"— " 3" × 3" " " "
but only contain the same number of bricks (128) per cubic yard in each case.

furnaces which would not work properly until their chambers had been reduced in length by nearly half.

**Chimney Flues.**—As already noted, it is important that the proportion between gas and air flues should be observed. As regards area, the temperature of waste gases in the flues being reduced to 600° C. (or under), their total volume will be reduced to two-fifths (or less) of that passing through the ports; and the flue areas could be reduced accordingly, with allowance for deposit and accumulation of flue dust, and for air leakages, etc. But they may well be made several times larger than this, and are preferably designed to correspond approximately with the chimney area in order to avoid sudden change of velocity. It is quite unnecessary, and probably undesirable, to make them too large, the result being simply to reduce the effectiveness of the ratio of air to gas areas. There is obviously no need to make the flue areas any larger than the port areas—in the present case 560 square inches and 1260 square inches respectively, and together 1820 square inches.

The point is also of interest in connection with dimensions of collecting flues below the checkerwork and the height and thickness of bearer walls, which are frequently built needlessly tall and thin and excessively weak for the weight they have to carry—and also in connection with plans for waste-heat boiler, etc.

On this basis, the flues being equal in depth, their respective widths will be in ratio of 2.25|1.00 (Fig. 3), and the dimensions will be approximately:

For gas flue, 560 sq. ins. = 2 ft. 0 ins. deep × 23 ins. wide.

For air flue, 1260 sq. ins. = 2 ft. 0 ins. deep × 52 ins. wide.

Plus 12″—18″ allowance in depth.

for flue dust accumulation, which brings their combined area reasonably near that of a 5 feet 0 inches diameter chimney.

The table gives the leading dimensions for furnaces of various sizes from the above data and on the same lines.

**Chimney Valves** should, of course, correspond to flue areas, and must be large enough to avoid any influence on the proportioning of the flues.

N.B.—With the same gas and only 10 per cent. excess air, the ratio comes down to 2.00|1.00

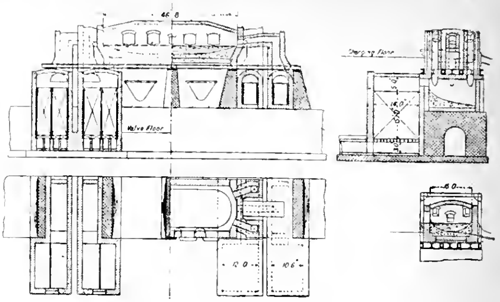


Fig. 5.—Design for 100-ton Basic Furnace as per calculations

**Waste-Heat Boilers.**

It is often considered a mistake to place boilers in the chimney flues of regenerative furnaces, on the ground that if regeneration is reasonably efficient there should be no material waste heat available, but the consumption of coal by a large open-hearth furnace—approximately 300 tons per 1,000 tons of ingots made—is sufficient to yield a great deal of steam, even on a very low evaporative basis, and there usually is a very material surplus heat in the gases passing up the chimney during at least some stages of the melt, if not during the later half of every reversal period. The lower strata of checkerwork may at times be cooled down to a black heat by the cold incoming air, but in the gas chamber they can never fall below the temperature of the incoming gas—so that the outgoing gases can never be cooled down on reversal to that temperature. The boiler's opportunity does, of course, depend on the thermal efficiency, or otherwise, of the regenerators and the length of the flues between them and the chimney; but, as already noted, the practical purpose of regeneration is not so much in extraction and economy of heat units, but in the provision and maintenance of high temperatures to the gas and air supplies—which is not quite the same thing as thermal efficiency. Checker chambers are rarely deep enough for high thermal efficiency, and considerable margin is therefore usually available for raising steam. Under suitable conditions, evaporation varies from one up to 3 lbs. of steam per pound of coal burned in the producers— though the latter figure must indicate very poor regeneration.

Table of Furnace Dimensions.

| Capacity | 20 Tons. | 40 Tons. | 60 Tons. | 80 Tons. | 100 Tons. |
|---|---|---|---|---|---|
| Hearth area at 7 sq. ft. per ton | 140 sq. ft. | 280 sq. ft. | 420 sq. ft. | 560 sq. ft. | 700 sq. ft. |
| Equivalent dimensions, say | 17′6″ x 8′0″ | 28′ x 10′ | 35′ x 12′ | 40′ x 14′ | 50′ x 14′ |
| Gas port area at 80 sq. in. per ft. hearth area | 112 sq. ins. | 224 sq. ins. | 336 sq. ins. | 448 sq. ins. | 560 sq. ins. |
| Equivalent dimensions | 10″ x 11″ | 15″ x 15″ | 18″ x 18½″ | 22″ x 20½″ | 24″ x 23″ |
| Air port area at 2.25 x gas port | 252 sq. ins. | 504 sq. ins. | 576 sq. ins. | 1008 sq. ins. | 1260 sq. ins |
| Equivalent dimensions | 2(10″ x 12½″) | 2(15″ x 16½″) | 2(18″ x 21″) | 2(22″ x 23″) | 2(24″ x 26″) |
| Gas checker chamber (6″ x 3″) | 28 sq. ft. | 56 sq ft. | 84 sq. ft. | 112 sq. ft. | 140 sq. ft. |
| Equivalent dimensions | 4′ x 7′ | 7′ x 8′ | 7′ x 12′ | 9′ x 12′ 6″ | 10′ x 14′ |
| Air checker chambers (6″ x 6″) | 31½ sq. ft. | 63 sq. ft. | 94½ sq. ft. | 126 sq. ft. | 157½ sq. ft. |
| Equivalent dimensions | 4′6″ x 7′ | 7′10″ x 8′ | 7′ 10″ x 12′ | 10′ x 12′6″ | 11′3″ x 14′ |
| Chimney flues, gas (12″) | 11″ | 15″ | 18″ | 22″ | 24″ |
| Chimney flues, air (12″) | 25″ x 22″ | 34″ x 27″ | 40″ x 30″ | 50″ x 33″ | 54″ ″98 x |
| Equivalent chimney diameter | 33″ | 41″ | 48″ | 54″ | 59″ |

N.B.- Actual chimney diameters should be calcu- than as given above, but these diameters should suf-
lated by the ordinary rules and will usually be larger fice if the height is correct.

Waste-heat boilers should be specially designed and well above their work as regards flue areas and heating surface, or results will be disappointing; for though evaporation may be only one pound of steam per pound of coal, the gases passing are virtually the same as if the coal were burning under it, or possibly eight times as much as though a coal-fired boiler doing the same duty. These dimensions depend on the weight of coal consumed, not upon the steam raised. Waste-heat boilers are usually fitted wtih mechanical induced draught plant, instead of the more reliable static chimney. By attention to flue and valve design, so as to do away with all obstruction other than the boiler, it is surely possible to dispense with mechanical draught and to retain the plain chimney and add sufficient to its height to equalise matters. The operation and output of the furnace must always be the first consideration.

### CONCLUSION.

Such are the general principles of open-hearth furnace design; and the author feels that if more attention were paid to their correct application, better performances would very often result. The data and assumptions made may not always correspond with actual conditions; but it is not a difficult matter to ascertain the latter more precisely and to amend the calculations accordingly, with due regard to the improvements it is desired to effect. The general reasoning and method will, he thinks, be found correct, and, he hopes, of value to all who are interested in the design and performance of open-hearth furnaces. It is surely better to tackle the subject ab initio, with a clear view of the objects and underlying principles, than to try to follow blindly the practice of others—British or foreign—who may, or may not, have "got there" by accident. Let us understand why, and possibly we may be able to improve thereon.

The metallurgy and practice followed are, of course, equally important factors in any comparison of performances, but are outside the scope of this article, and must be reserved for a future paper.

## A SIMPLE BUT VALUABLE INVENTION.

An interesting patent was taken out within the last two or three years by the Steel Co. of Canada, for Mr. C. W. Hawthorne, the late superintendent of their Rod and Billet Mills, who was the author of the idea.

In the Rod Mill of this company, as installed by the Morgan Construction Co., of Worcester, Mass., the billet (about 1¾" square), is taken from the heating furnace by means of a pusher operated by a friction drive. The mill is a continuous one, and the billet, on coming from the furnace, immediately enters the first pass of rolls; the grip of these rolls on the billet pulling it the remainder of the way from the furnace and starting it in its course through the rolls.

Considerable trouble was experienced with this first pass on account of slipping, due to the scale that had accumulated on the billet while passing through the heating furnace, and in the original installation a special roll was used at this point to help to avoid the slip. This special roll was expensive and not desirable if it could be avoided.

The simplicity of Mr. Hawthorne's idea which got over this trouble is perhaps the most interesting part of the patent. The friction drive, used to operate the pusher, consisted simply of two rollers driven by power the distance between them being regulated by a foot lever. The pusher was a square steel rod with a sort of claw, a thumb and finger effect, at one end, which gripped the billet while it shoved it out of the furnace.

Mr. Hawthorne's patent consisted in giving a half turn to the long square shaft of the pusher which passed through the friction rolls, so that as the rolls carried the pusher along (and so shoved the billet out of the furnace) they also gave the pusher a half turn. The billet gripped by the claw of the pusher also was given a half turn and the scale all rolled off leaving a clean billet to enter the rolls.

This simple little operation, easily performed by any blacksmith in a few minutes, proved very effective. The patent was purchased from Mr. Hawthorne by the Morgan Construction Company for a good figure.

## VICTIMS OF INFLUENZA IN HAMILTON.

Mr. Charles Snyder, who until a few months ago, held the position of Assistant Accountant at the Steel Co. of Canada, and since that time has been with The Buffalo Bolt Co., Tonawanda, Buffalo, has been ill with Spanish influenza together with all his family. It is with the deepest regret that we have heard of the death of his wife from this disease. Mrs. Snyder passed away on October 21st. The family have many friends in this city and very much sympathy is felt for them in this sad bereavement.

After a few days illness of Spanish influenza, Mr. Melville A. Kemp passed away at St. Joseph's Hospital on Saturday, October 19th. Mr. Kemp has been in the city nearly two years in the Shell Component Inspection Department of the Imperial Ministry of Munitions.

Mr. Kemp had received his B.Sc. degree from Queen's University, graduating in 1912. He was also a member of the newly organized Hamilton branch of the Engineering Institute of Canada. Mr. Kemp leaves a young widow besides his many friends to mourn his loss.

It is with deep regret that we have to record the death of Mrs. Haviland, wife of Mr. F. L. Haviland, Assistant Chief Draughtsman at the Hamilton Bridge Works Co., Ltd. Mrs. Haviland died of pneumonia brought on by Spanish influenza after a very short illness. Their many friends extend their deepest sympathy to the bereaved husband and daughter.

## "ACID VERSUS BASIC STEEL FOR CASTINGS."

By EDWIN L. CONE, New York.

The above paper, which appeared in the last number of Iron and Steel, was presented at the Cleveland meeting of the American Foundrymen's Association, September, 1917. We regret that we were unable to give due acknowledgment at the time.

We also wish to correct some figures appearing in this paper on page 362 of our last issue. The percentage of oxygen in acid open-hearth steel should have been 0.010; the percentage in basic open-hearth steel 0.019, was correct.

## NON-METALLIC INCLUSIONS: THEIR CONSTITUTION AND OCCURRENCE IN STEEL.

By ANDREW McANCE, D.Sc., A.R.M.S.
(Glasgow.)

(Concluded from the October Issue.)

### Oxide Inclusions.

In some basic steel containing 0.09 per cent. carbon which came under the author's notice, there were numerous black inclusions which were particularly hard, and could only be dislodged with the greatest difficulty. On analysis they gave the composition A, Table IV., proving them to be a mixture of manganous and ferrous oxides, to the extent of 94.5 per cent. Under the microscope such inclusions seemed to consist of an agglomeration of small round particles of a dove

TABLE VI.

| | $SiO_2$. | MnO. | FeO. | CaO. | $Al_2O_3$ |
|---|---|---|---|---|---|
| A | 1·42 | 66·24 | 28·28 | nil | 4·30 |
| B | 10·18 | 59·05 | 27·01 | 0·84 | ... |
| C | 7·71 | 60·45 | 23·82 | 5·92 | ... |
| D | 5·0 | 70·0 | 21·2 | trace | 0·52 |
| E | 54·2 | 27·1 | 8·04 | nil | 9·97 |

grey colour (Plate VII., No. 31)x which had coalesced to form larger masses, and which possess in consequence a network structure very similar to mixtures of ferrous oxide and silica. Etching with reagent A darkened this network constituent, indicating that it was a silicate, and close examination revealed two silicates which from the chemical analysis must be those of iron and manganese. At the same time the oxide itself was attacked, producing a rayed structure which gave the inclusions a very striking appearance.

The silicon in the steel was 0.014 per cent., and the low silica content of the inclusion is a direct consequence of this. No. 32, taken after etching, shows how the isolated globules were only attacked round the outer edges where they could be reduced by the silicon in the steel to silicate, and it also gives a good idea of the rayed structure of the oxide. The absence of lime in the analysis proves that the inclusion was not derivable from slag.

Similar inclusions have been previously discovered, and they only occur in basic steels of low silicon. Ruhfus[47] gives several analyses (B and C, Table V.), and he describes the material as a grey-green powder. Saniter[48] found a mass 1 inch in diameter in an ingot with the composition D, Table V. Baraduc-Muller[49] allowed an ingot to solidify in a vacuum, and on the top surface there was a scum which weighed 0.8 lb. per ton of steel and analysed E, Table V. Since there is no lime in this sample it must have been derived from the same source as the oxide inclusions above, though it is contaminated with firebrick material. The ratio of manganese to iron in such inclusions precludes the possibility of their having been formed from the simple oxidation of the ferro-manganese, which has been added for deoxidation purposes.

The occurrence of inclusions of this type is of the utmost importance, for such cases prove that FeO and MnO are present in the steel which fills the mould, and they must in consequence be derivable from the steel. It has been widely asserted, of course, by practical steelmakers, that ferrous oxide is soluble in steel, and steel containing blowholes is generally referred to as "oxidised steel" and submitted as prooof of the assertion.

But the very simplicity of the logic should make us scrutinise the evidence with greater care.

Law[50] was the frst to recognise that certain specks visible under the microscope in brittle and blistered steel sheets might be oxide, and a little later he was able to prove that his surmise was correct. These oxide specks are only visible under high powers, and they disappear on heating in hydrogen. The steels in which they occur only contain a trace of silicon. A similar type of inclusion has been found by Humfrey[51] in transformer sheets which have been heated in an atmosphere containing $CO_2$ at reduced pressure, and he showed that such specks were equally insoluble in γ and a iron. The steel used contained 0.02 per cent. carbon and 0.098 per cent. silicon.

By melting iron rods electrically in the presence of scale Austen[52] produced metal which contained by analysis 0.28 per cent. oxygen and showed the characteristic specks of oxide, while in addition there were a number of much larger inclusions which possessed a duplex structure, but whose composition was not determined. From their appearance, however, they are probably iron scale containing a proportion of $SiO_2$. Plate VIII., No. 33, shows a structure closely similar to that of Austen's inclusion,[53] which was obtained by cooling quickly a mixture of iron scale and 3 per cent. of silica. Owing to the oxidising conditions during the melting period the resulting scale has evidently become mixed with the molten metal.

The author has met with oxide specks in bath samples taken from the acid open-hearth furnace and the electric furnace, and in several cases where they have occurred there were minute inclusions along with them, associated in such a manner that the inference seemed to be justified that these inclusions had been derived from the oxide specks. But they do not seem to occur in steels containing over 0.1 per cent. of silicon as a rule, although there are exceptions. A casting from a very cold heat after annealing was found to possess its original casting structure still, and no heat treatment was able to break the structure up. The pearlite areas rearranged themselves quite satisfactorily, but the material fractured readily and always showed the fir-tree pattern of the casting crystals. Under the microscope the reason for this was apparent, because between every crystal grain there occurred numerous small silicate inclusions in chains outlining the original crystal grains (No. 34). A fracture in consequence followed those lines of weakness and gave rise to the original casting structure, even though the true grain size was small. In this specimen also there were numerous

x—See earlier portion of this article.

[47]Stahl and Eisen, vol. xvii., p. 41.

[48]Journal of the West of Scotland Iron and Steel Institute, 1917, p. 93.

[49]Iron and Steel Institute: Carnegie Scholarship Memoirs, 1914, p. 216.

[50]Journal of the Iron and Steel Institute, 1906, No. 1, p. 134; 1907, No. II., p. 94.

[51]Iron and Steel Institute: Carnegie Scholarship Memoirs, 1912, p. 80.

rosettes of oxide notwithstanding that the silicon was over 0.1 per cent.

The occurrence of such minute specks is, however, very far removed from the occurrence of masses such as A, B, and C, Table VI., in sufficient quantity to analyse, and it may be doubted whether these are merely modes in the occurrence of the same substance. But no definite statement could be made on this point unless the melting points of the pure oxides of iron and manganese were known. For it might be that the specks were solid particles of the oxides which could not coalesce, and that only in the presence of silicon could they be rendered fusible, through the formation of silicate, and so be enabled to unite to form the larger masses represented by A, Table VI.

But it may be taken as proved that oxides are present in liquid steel, since the evidence of inclusions, though meagre, is sufficiently definite.

**Equilibrium Conditions in Liquid Steel.**

In previous sections the endeavour has been made to show how the many complex types of inclusion can be derived from simpler substances by interaction with the constituents of the steel, and among the simple substances a most, if not the most, important role is played by ferrous oxide. Before the trouble caused by the presence of inclusions can be lessened, it is necessary to find out how the oxygen compounds present in liquid steel are affected by the alteration of the chemical and physical conditions, and although the inquiry will be largely theoretical the results of practical experience will be always at hand to test the theoretical deductions.

The analytic determination of oxygen in steel cannot lead to any definite pronouncement on the subject. The result indicates oxides in the steel, but not necessarily in solution, just as the methods of estimating silicon do not distinguish between soluble silicon and insoluble silica. It will be evident that any inclusion containing reducible oxide will give a high value, and yet it would not be correct to say the metal was highly oxidised. This is specially the case with wrought iron, which generally gives an abnormally high value for the oxygen content.[54] On heating such irons containing inclusions of FeO or $Fe_2O_3$ and their mixtures, any carbon if present will react to form CO, which in turn will be reduced by the hydrogen and estimated as hydrogen. This loss of carbon even in a reducing atmosphere has already been commented on.[55]

It is necessary to distinguish three possible forms of oxide compounds in steel, (1) as oxide inclusions, (2) as solid oxides in solution, (3) as gaseous oxygen compounds in solution, and the first has already been dealt with.

The occurrence of inclusions of type A, Table VI., is a proof that FeO and MnO are present in liquid steel. Such inclusions only occur in the absence of silicon, since when silicon is present as in acid steels they are rapidly reduced to form silicates (D, Table III.). But their genesis must be the same in both cases. In what form these oxides occur, however, remains to be determined, and this question can now be considered.

If liquid steel contains FeO in solution the amount will be entirely independent of the outside pressure, just as the quantity of salt soluble in water is independent of atmospheric pressure. But if CO or hydrogen are in solution the concentration of the solution will be proportional to the pressure of the surrounding atmosphere. How does liquid steel then behave under reduced pressure? The experiments of Baraduc-Muller[56] show that it parts with its gases, proving that both carbon monoxide and hydrogen are in solution per se. They will thus obey the general laws of gases in solution in liquids, and a rise in temperature of the solution will cause diminished solubility, while the solid solution will have a greatly decreased concentration of the gas compared with the liquid solution at the same temperature. This latter point is recognised, and is supported by the experiments of Goerens,[57] who found that the quantity of gas in solid steel behaved in its segregation like carbon.

In the acid open-hearth process the reduction of the carbon takes place according to the equation

$$C + FeO = CO + Fe \quad . \quad . \quad . \quad . \ (1)$$

and since equilibrium can be attained and the carbon and carbon monoxide are admittedly in solution, it follows that the FeO must also be in solution in the steel. It is important to note that the reduction of the carbon only takes place when the silicon and manganese have been reduced to traces, for so long as either of these elements is present the carbon is untouched. There is the possibility in view of this reaction that all the CO given off during the solidification of steel does not exist as a solution of gas when the steel is liquid, but is formed during the process of solidification through the interaction of the FeO with the carbon, according to equation (1). In the experiments of Baraduc-Muller,[59] which are the only accurate ones available on the subject the quantity of CO given off was equivalent to 0.09 per cent. by weight, and if produced by interaction with carbon would have caused a loss of carbon equivalent to 0.04 per cent. But the carbon of the converter metal was 0.05 and the ferro-manganese added 0.04, so that no less of carbon has taken place because the finished metal analysed 0.09-0.10 per cent. The expulsion of CO causes no decrease in the percentage of carbon, so that it can be concluded that the FeO and CO in solution in this particular liquid steel did not form a system in equilibrium with the carbon. Ths steel contans 0.55 per cent. manganese and 0.007 per cent. silicon, and the important conclusion follows that in any steel after it leaves the furnace the same conditions exist as in the melting stages of the acid open-hearth process and the carbon is not reduced so long as manganese or silicon is present. Equation (1) therefore does not govern the conditions which occur in liquid steel containing deoxidisers during solidification.

---

[52]Journal of the Iron and Steel Institute, 1915, No. II, p. 157.

[53]Ibid., p. 160, Fig. 4.

[54]Pickard, Iron and Steel Institute Carnegie Scholarship Memoirs, 191, p. 70.

[55]Ibid., p. 72.

[56]Loc. cit.

[57]Ferrum, 1916, p. 149.

[58]Loc. cit.

[59]Boudouard, Annales Chem. Phys., 1901, vol. xxiv, p. 5. Hahn, Zeits. physik. Chem., 1903, vol. xlii., p. 705; vol. xliv., p. 153.

Another reaction is possible, however,

$$FeO + CO = CO_2 + Fe \quad . \quad . \quad . \quad . \quad (2)$$

and the equilibrium conditions with solid Fe and FeO have been worked out up to about 1000 deg C[60], Very complicated conditions may be set up, including the formation of $Fe_2O_3$, but for the present they need not be discussed. At 1000° C. a mixture of about 20 per cent. $CO_2$ and 80 per cent. CO is in equilibrium with FeO and Fe, and as the temperature increases the proportion of $CO_2$ gets less.

If these three substances, FeO, CO, and $CO_2$ in solution in steel, are in equilibrium at constant temperature, then in accordance with equation (2)

$$\text{Constant} = K = \frac{C_{CO_2}}{C_{FeO} \cdot C_{CO}} \quad . \quad . \quad . \quad . \quad (3)$$

where $C_x$ is the concentration of X.

Several deductions can be drawn from this equation, which are in agreement with experimental facts already ascertained. For instance, it explains why a certain proportion of $CO_2$ is always present in the gases drawn off from steel. In accordance with the ascertained equilibrium constants the proportion of $CO_2$ to CO should decrease with rising temperature. Hailstone[60] has measured the gases given off by a certain cast iron when cast at decreasing temperatures, and his results thoroughly agree with this deduction.

| No. | Temperature of Casting. | CO per cent. | CO per cent. | Ratio per cent. |
|---|---|---|---|---|
| 1 | 1428 | 0.98 | 29.62 | 3.30 |
| 6 | 1348 | 1 82 | 25.05 | 7.26 |
| 10 | 1264 | 3.21 | 23.03 | 13.93 |

If the gases are drawn off from liquid steel by reducing the outside pressure they should come off, so that the ratio $\frac{CO_2}{CO}$ is constant, and there will be left to solidify a steel containing FeO in solution, but no gases. The ratio of $CO_2$ to CO in the gases in Baradue-Muller's results taken at intervals from the end of teeming to the commencement of solidification of the top crust was as follows:

| Period. | $CO_2$ per Cent. | CO per Cent. | Ratio $CO_2$ CO per Cent. |
|---|---|---|---|
| 1 | 5·2 | 43·2 | 12·0 |
| 2 | 4·0 | 56·8 | 7·0 |
| 3 | 4·8 | 40·8 | 11·8 |
| 4 | 2·8 | 24 8 | 11·3 |

The constancy must be considered good, considering the difficulty of the experiment and the small number of observations. After solidification has started the temperature conditions of the equilibrium no longer hold of course. These facts offer justification for equation (2), representing the condition of equilibrium of liquid steel containing manganese, silicon, or aluminium. Although this conclusion may seem rather arbitrary, it is merely the expression of the fact that the equilibrium conditions of FeO are dominated by the element which has the greatest affinity for oxygen. Aluminium, silicon, and manganese when they are present determine the amount of free FeO, and only in the absence of these does the carbon enter into the reaction.

[60] Iron and Steel Institute; Carnegie Scholarship Memoirs, 1916, p. 66.

Although the gases can be removed from steel without affecting the amount of FeO, in accordance with equation (3), the converse is not true. If the concentration of the FeO is reduced the reaction proceeds from right to left, and the concentration of $CO_2$ also gets less, and the ratio of CO to $CO_2$ increases correspondingly, until a balance is once more attained. A reduction of the FeO means therefore a reduction of the total gases, and in steel free from blowholes the FeO has been reduced to such an extent that the total quantity of gases corresponding do not saturate the solid steel at its solidifying temperature. Steel free from blowholes, therefore, does not necessarily mean steel free from gases.

A large amount of experimental work has been done in determining the composition of the gases given off when solid steel is heated in a vacuum, but only broadly qualitative general conclusions have been drawn from the results, and from the above consideration of the equilibrium conditions this is not surprising, since the gases found in the solid state bear little relation to the gases originally contained in the liquid metal. Their composition has been modified by partial equilibrium at lower temperatures, by the extent of the deoxidation, and in addition by the furnace conditions during working.

All the evidence is favourable to the view that FeO is in solution in liquid steel. It follows that the addition of elements having a stronger affinity for oxygen than iron has, will reduce both the amount of FeO and the amount of gases in solution.

$$Mn + FeO = Fe + MnO \quad . \quad . \quad . \quad (4)$$

and the oxides so formed, if uncombined further, will form inclusions of the type A, Table VI. It is an astonishing fact that inclusions of this type taken under conditions widely different and relating both to early practice (1896) and to the most recent practice (1917) should have compositions so closely similar. The MnO only varies from 60 to 70 per cent. and the FeO from 21 to 28 per cent. It cannot be coincidence, but must be the expression of equilibrium conditions between the FeO and the MnO. This would explain why steel cannot be completely deoxidised by manganese alone, unless the percentage of manganese is very high, and why it is necessary to use a large excess of manganese in proportion to the sulphur content. The idea of equilibrium between Mn and FeO might be thought to be contrary to the experiments and conclusions previously detailed but the present case concerns free oxides whereas the previous section dealt with FeO in combination with silica.

Silicon and aluminium also act strongly, of course, on FeO, and their effect on the FeO gas equilibrium will be similar to that of manganese greatly enhanced. A great amount of experimental work is necessary, however, before the mutual effect of one reaction on another when all are possible can even be conjectured.

Ferrous oxide in the steel will, from what has been said in previous sections, form mixtures of iron and manganese silicates, and ultimately manganese silicate only. It is an influence for evil in every class of steel, for when it is not removed it is the cause of blowhole formation, and when removed from solution it leaves as a non-metallic inclusion a record of its previous existence.

### The Influence of Temperature on the Prevalence of Inclusions.

The influence of temperature on the number of inclusions in a steel ingot has already been considered from a purely physical aspect, and it was concluded that a greater freedom from inclusions was to be expected if the temperature of the steel was raised. And it need not again be pointed out that by high temperature a relative comparison of ordinary working conditions is intended. The question of temperature from a chemical standpoint will now be considered, but first of all let the facts be put forward.

To determine the prevalence of inclusions in any sample of steel it is very useful to etch for five to six hours with a hot 20 per cent solution of sulphuric acid, when the inclusion will be attacked first and deep pits left where they existed. For comparison purposes sections were taken from slabs rolled from ingots which were known to have been cast from the extreme limits of the pyrometric scale of casting temperatures. The ingots were the same size, and the slabs were sectioned the same distance up from the bottom end, while the compositions were similar, so that all the conditions were as far as possible the same. The photos after hot acid etching (Nos. 35 and 36) show a great difference in the number of inclusions, a difference which the sulphur prints confirm, the ingot cast hot having a much fewer number than the cold cast ingot.

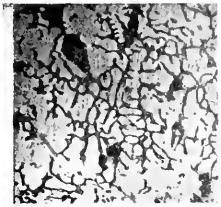
A statistical record of the number of rejections due to defects traceable to inclusions which have arisen during machining has been made over a considerable period with one class of forging, and the results have been classified according to the casting temperature as hot, medium, and cold heats. Putting the percentage of defects in the first case at unity the other heats gave the following comparative results:

| Hot. | Medium. | Cold. |
|---|---|---|
| 1 | 1.88 | 2.44 |

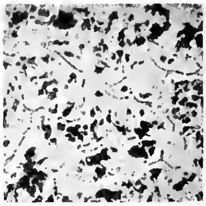
These have been confirmed over another period equally long, and the ratios were almost identical, so that they leave no doubt that a high temperature of casting is beneficial in the production of steel free from inclusions.

In the class of inclusions formed by admixture, which embraces slag and fluxed firebrick and also with MnS inclusions, a high temperature is beneficial for reasons which are purely physical, such as the increased fluidity and longer time of setting in the moulds.

For inclusions which have been derived from dissolved FeO, the number will depend on the amount of FeO available, and this can only be controlled by the furnace conditions. In the finishing stages of the open-hearth processes, equilibrium is practically attained between the reactants in the equation (1). This reaction has a negative heat balance, and so a rise in temperature means that it will proceed from right to left, and less FeO will be in equilibrium with the same amount of carbon and CO. Just how much less can be calculated and for a rise of 50 deg. C. from 1550 to 1600, the difference in the equilibrium constant is at least 25 per cent. This is a very large difference for a temperature variation which is well within practical conditions. Since the carbon content is generally in the neighbourhood of 0.15 per cent at the finishing stage for most classes of steel in acid open-hearth practice, and the steel at most is saturated with CO, the concentration of two of the reactants will be practically constant, and the 25 per cent difference means a 25 per cent difference in the amount of dissolved FeO.



No. 33



No. 34

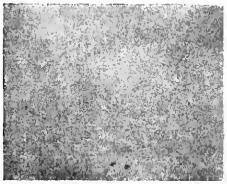


Plate VIII.

No. 33. $\times$ 100. Iron scale containing 3 per cent $SiO_2$.

No. 34. $\times$ 100. Original casting crystals outlined by non-metallic inclusions.

No. 35. Scale 1/5. Section of slab cast "hot." Etched with $H_2SO_4$.

No. 36. Scale 1/5. Section of slab cast "cold." Etched with $H_2SO_4$.

Nor does the influence stop here, for the slag is in equilibrium also with the constituents in the steel, and by the partition law the concentration of the FeO in the slag bears a constant ratio to its concentration in the steel. A high temperature of working therefore implies not only less FeO in the steel but also a more siliceous slag. Every practical acid steelmaker will agree that this deduction from theory is in accordance with experience, and that hot working charges finish with a more siliceous slag than cold-working charges. The concordance between the practical facts and the theoretical deductions shows the correctness of the underlying theory and the vast importance of equilibrium conditions in the metallurgy of steel.

---

The new machine shop for the Ford Smith Machine Co., Ltd., which is located on Cavell Ave., is almost completed, and it is expected that it will be ready for occupation by November 1st. The new shop, which will replace three others now in operation, is a very fine building 352 ft. long by 60 ft. wide. It has a travelling crane down the centre, and is amply equipped with store rooms and office accommodation. The building is finished inside in white.

W. H. Cooper is contractor for the building, and much credit is due him for the fine result.

# The Influence of some Elements on the Tenacity of Basic Steel

## With a New Formula for Calculating the Maximum Load from the Composition

By ANDREW McWILLIAM, D.Met., A.R.S.M.,

(Metallurgical Inspector, Government of India, Indian Munitions Board.)

(English Iron and Steel Institute, Sept., 1918).

For many years before coming to India the author was mildly interested in formulae for calculating the tensile strength of steels of known composition and normal treatment, but found them all unsatisfactory for use on the very varied series and high range of tempers made at the University of Sheffield as well as on the general line of those produced commercially in steelworks in Sheffield.

On coming to India he felt the desirability, in connection with the work of inspection, of obtaining a formula which would give reasonably correct results within the range of the British Standard Specifications for structural steels that is, 28 to 32 tons per square inch maximum (since altered to 28 to 33 tons), and this was fairly easily accomplished. When steels much above the British Standard in tenacity came to be required in Sakchi the empirical formula broke down, and a strenuous endeavor was made to obtain one on a rational basis. It was felt that by estimating carefully the tenacity of pure iron and the effects of the various elements present, and of their influences on one another, it should be possible to evolve a formula that would agree with the tensile strength obtained on the testing machine within about 1 ton for steels within the limits of the British Standard Specification for structural steels, and within about 2 tons for tempers above, say, 40 tons per square inch. Assuming results for the various elements that were fairly well established for the lowest tempers, and deducting the totals from tests of very mild material, the strength of absolutely pure iron was estimated to be about 38,000 lbs. or 17 tons per square inch.

In all the calculations that follow the sections of the steel bars are assumed to be of the order of 1 inch round, or other sizes that would not differ much from these in tenacity, and the condition of the materials to correspond with that represented by the term "normalized." In stating the effect of any element of the tenacity of the steel the unit of the element will be taken at 0.01 per cent.

It seemed to be fairly generally recognized that phosphorus adds about 1,000 lbs. per unit, and this effect was accepted in the preliminary series of calculations, which pointed to the figure 100 lbs. as being nearest to the effect of manganese in the lower tempers. The silicon in the steels was so low that it could be ignored, but afterwards was estimated to be about 120 lbs., and as sulphur is generally considered, and from the mode of its occurrence in the steel would be expected to have very little effect on the tenacity, its influence was ignored, especially as the sulphur in the steels was generally below 0.03 per cent.

In a series of carefully tested steels of from 0.20 to 0.26 per cent carbon this left the influence of the carbon at about 800 lbs. per unit, so that the first attempted rational formula for steels within the older British Standard of 28 to 32 tons was:

$$\text{Maximum load in lbs. per square inch of original section} = 38{,}000 + 800\ C + 100\ Mn + 1000\ P.$$

When basic steels were made of from 33 to 50 or 60 tons per square inch the formula was tried, and found, as with others, to fail. The problem of obtaining the separate effects of the added elements is a most complicated one, and is made still more difficult by the fact that results obtained in works practice on the testing machine, even when the test-piece itself is analyzed, vary more than the differences that one would care to allow between the general results of the calculations from the compositions and those obtained by testing. This being so, the only way seemed to be to calculate hundreds of tests so as to eliminate so far as possible the effect of the variations in the test results. It is almost impossible to be certain, owing to these variations that the correct value has been assigned to each of the elements present, especially considering the different effects of the elements in the presence of one another; but one comforting result of the hundreds of calculations made is, that the elements seem to preserve their individual effects much more strongly than might have been supposed.

In searching for a reason why the formula that gave correct results round 0.2 per cent. carbon, gave results were too low at say 0.5 per cent carbon, it was thought that as the carbon would be present in the form of pearlite to which the added strength was due, the more pearlite present the greater effect the carbon would have per unit on the tenacity of the mass, and that as the manganese influenced the nature of the pearlite its influence would increase with increasing proportions of pearlite. Another long series of calculations was then made on the ordinary results obtained day by day, supplemented by as many as possible from our records, with the result that the effect on tenacity per unit of carbon present was shown to increase with the amount present, and that the same appeared to be the case for manganese. The figures obtained were at 0.2 per cent carbon about 800 lbs. per unit of carbon, rising apparently quite regularly to somewhere about 1,000 lbs. at 0.7 per cent carbon, although the upper figure is not so reliable as the lower, owing to the very much smaller number of tests on which it has been based. The manganese in the same range seemed to vary in effect from about 100 lbs. at 0.2 per cent carbon to 200 lbs. at 0.7 per cent carbon. These are shown graphically in Fig. 1.

Later from published and other records, the silicon used was estimated to add about 120 lbs. per unit, so the formula is now

$$\text{M.L.} = 38{,}000 + [800 + 4\,(C - 20)]\,C + 120\ \text{Si} + [100 + 2\,(C - 20)]\ \text{Mn} + 1{,}000\ \text{P}.$$

M.L. representing the maximum load in lbs. per square inch of original section. This formula has stood the test of trial wonderfully well. Even with the higher silicon shell steels it has given good results.

On reading Dr. Stead's paper of Sept., 1916,[1] it was decided to extend these results and put the matter in shape for a paper to the Institute, in the hope that the formula would be tested by many of the members, criticized in detail, and that, ultimately, if found defective to any marked degree, a new one would be obtained that would apportion the correct effect to each element. One's own steels are apt to run in lines, and do not show the defects in a formula which might be obtained when many makers and experimenters test it on their results. To simplify

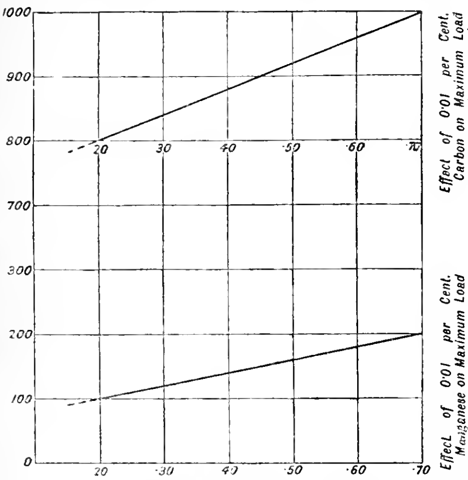



FIG. 1.—Effects of 0·01 per Cent. of Carbon and of Manganese respectively on Maximum Load in lbs. per square inch of original section.

the calculations a table is appended giving the effect by the formula of each amount of carbon from 0.10 to 0.75 per cent., allowing extrapolation from 0.2 to 0.1, and from 0.7 to 0.75. There seems little doubt that not far above 0.75 per cent. the value per unit of carbon begins to decrease. So far the formula had sufficed for our own needs, but in preparing the material for publication it was felt that it should be tested on reliable published results.

Turning first to Arnold's classical carbon series of pure crucible steels, it was found that for his steels within the range, namely, No. 1 with 0.08 per cent., No. 1½ with 0.21 per cent. No. 2 with 0.38 per cent, No. 3 with 0.59 per cent. carbon, the formula gave for

TABLE I.—*Effect of Carbon from 0·1 to 0·75 per Cent. on the Tenacity of Basic Steel. The Tenacity of Pure Iron being taken at 38 000 Lbs. or 17 Tons.*

| Carbon per Cent. | Lbs. per Sq. Inch. | Tons per Sq. Inch. | Carbon per Cent. | Lbs. per Sq. Inch. | Tons per Sq. Inch. | Carbon per Cent. | Lbs. per Sq. Inch. | Tons per Sq. Inch. |
|---|---|---|---|---|---|---|---|---|
| 0·10 | 7,600 | 3·4 | 0·32 | 27,136 | 12·1 | 0·54 | 50,544 | 22·6 |
| 0·11 | 8,404 | 3·8 | 0·33 | 28,116 | 12·6 | 0·55 | 51,700 | 23·1 |
| 0·12 | 9,216 | 4·1 | 0·34 | 29,104 | 13·0 | 0·56 | 52,864 | 23·6 |
| 0·13 | 10,036 | 4·5 | 0·35 | 30,100 | 13·4 | 0·57 | 54,036 | 24·1 |
| 0·14 | 10,864 | 4·9 | 0·36 | 31,104 | 13·9 | 0·58 | 55,216 | 24·7 |
| 0·15 | 11,700 | 5·2 | 0·37 | 32,116 | 14·3 | 0·59 | 56,404 | 25·2 |
| 0·16 | 12,544 | 5·6 | 0·38 | 33,136 | 14·8 | 0·60 | 57,600 | 25·7 |
| 0·17 | 13,396 | 6·0 | 0·39 | 34,164 | 15·3 | 0·61 | 58,804 | 26·2 |
| 0·18 | 14,256 | 6·4 | 0·40 | 35,200 | 15·7 | 0·62 | 60,016 | 26·8 |
| 0·19 | 15,124 | 6·8 | 0·41 | 36,244 | 16·2 | 0·63 | 61,236 | 27·3 |
| 0·20 | 16,000 | 7·1 | 0·42 | 37,296 | 16·7 | 0·64 | 62,464 | 27·9 |
| 0·21 | 16,884 | 7·5 | 0·43 | 38,356 | 17·1 | 0·65 | 63,700 | 28·4 |
| 0·22 | 17,776 | 7·9 | 0·44 | 39,424 | 17·6 | 0·66 | 64,944 | 29·0 |
| 0·23 | 18,676 | 8·3 | 0·45 | 40,500 | 18·1 | 0·67 | 66,196 | 29·6 |
| 0·24 | 19,584 | 8·7 | 0·46 | 41,584 | 18·6 | 0·68 | 67,456 | 30·1 |
| 0·25 | 20,500 | 9·2 | 0·47 | 42,676 | 19·1 | 0·69 | 68,724 | 30·7 |
| 0·26 | 21,424 | 9·6 | 0·48 | 43,776 | 19·5 | 0·70 | 70,000 | 31·3 |
| 0·27 | 22,356 | 10·0 | 0·49 | 44,884 | 20·0 | 0·71 | 71,284 | 31·8 |
| 0·28 | 23,296 | 10·4 | 0·50 | 46,000 | 20·5 | 0·72 | 72,576 | 32·4 |
| 0·29 | 24,244 | 10·8 | 0·51 | 47,124 | 21·0 | 0·73 | 73,876 | 33·0 |
| 0·30 | 25,200 | 11·3 | 0·52 | 48,256 | 21·5 | 0·74 | 75,184 | 33·6 |
| 0·31 | 26,164 | 11·7 | 0·53 | 49,396 | 22·1 | 0·75 | 76,500 | 34·2 |

No. 1, 20.8 tons compared with 21.39 tons, or 47,914 lbs. by test.

No. 1½, 25.8 tons compared with 25.39 tons, or 56,874 lbs. by test.

No. 2, 33.3 tons compared with 29.94 tons, or 67,066 lbs. by test.

No. 3, 43.8 tons compared with 42.82 tons, or 95,917 lbs. by test.

These results are in fairly close agreement, unless for No. 2. It is noted that between 1 and 1½ the carbon adds 689 lbs. per unit to the tenacity, between 1½ and 2, 600 lbs., between 2 and 3, 1,374 lbs.; or, again, 1 to 1½, 689 lbs.; 1 to 2, 638 lbs.; 1 to 3, 941 lbs.; or, allowing for the slight differences with other elements present, from 1 to 1½, 648 lbs.; 1½ to 2, 596 lbs.; 2 to 3, 1,329 lbs.; or 1 to 1½, 648 lbs.; 1 to 2, 618 lbs.; 1 to 3, 916 lbs. It is interesting to note that, according to these calculations, the tenacity of pure pearlite and normalized would be almost exactly 51 tons per square inch, as given by eliminating the calculated effect of the impurities present.

The author's results were obtained by trial and error, by calculation on each day's work, and he had not thought of comparing the results with Arnold's series during the trials. Since the attempt to get a formula on a rational basis began, the same constant of 38,000 lbs. or 17 tons for the iron has been used. The first formula of 800 C + 100 Mn + 1,000 P served well until we began to make the test steels above 0.4 carbon, and then it was found that results near enough to the test results could not be obtained by the formula but were given by raising the carbon figure to 900 and the manganese figure to 150. Then above about carbon 0.6 per cent it was found necessary to raise these figures again to 1,000 and 200 respectively As no sign of an abrupt change was detected, it was then decided to take the even change from 800 C at 0.2 to 1,000 C at 0.7, as already stated.

In Fig. 2 these results are plotted for comparison. The full line shows Arnold's carbon series normalized, the dotted line representing the same series with the total values for the small quantities of impurities present eliminated. The curved line shows the carbon

[1] "Influence of some Elements on the Mechanical Properties of Steel," Journal of the Iron and Steel Institute, 1916, No. II.

values as obtained by a long series of trial and error calculations on ordinary commercial steels, the composition of the test-pieces used, in cases of special interest for the curve, being checked by analyses of the test-pieces.

One point to be determined is whether in the commercial steels there is a sudden change in the value of the carbon between 0.38 and 0.59 — a region containing the half pearlite, half ferrite steels, or whether the effect of the carbon is represented by a smooth curve. The author's calculations so far indicate a smooth curve between 0.2 and 0.7 per cent carbon, although the method is not so apt to detect a sudden change of direction in the curve as the direct method of experiment.

In connection with any effect of phosphorus one instinctively turns to Stead's results, and taking his well-known series of three with 0.041, 0.302, 0.509 per cent phosphorus, it was found that, allowing for the effects of the other elements present, the phosphorus in the 0.041 sample was represented by 880 lbs., in the 0.302 by 620, and in the 0.509 by 550 lbs., whilst in Arnold's 1.37 per cent phosphorus steel the phosphorus only added about 150 lbs. per unit to the tenacity. At first sight these results do not seem to lend much countenance to the estimate of 1,000 lbs. per unit of phosphorus for steels containing up to 0.03 per cent. phosphorus, but on plotting them as a curve they are seen distinctly to support the view and to point to the correctness of the usual estimate of

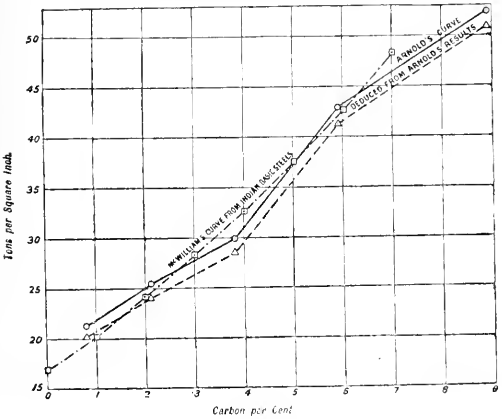



Fig. 2.—Curves showing Influence of Carbon on Tenacity of Iron.

the value of phosphorus, which although it has been taken in all these steels at 1,000, may be 900 for those containing 0.03 to 0.06 per cent. The value of silicon has been gathered from published results, such as Baker's. For Arnold's silicon steel the formula gives 31.6 tons compared with 31.7 tons by test.

The author would like his friends, whilst critically examining each part of the formula, to pay particular attention to the manganese, as there most of the differences in opinion seem to be with reference to this element. As we are attempting to obtain general agreement in a series of, say, a day's work within 1 ton up to 33 tons with only an occasional member of the series beyond, and within 2 tons for higher tempers, and 0.03 per cent carbon represents over 1 ton in tenacity, it is not much use taking special notice of divergencies unless the test-piece is analyzed,

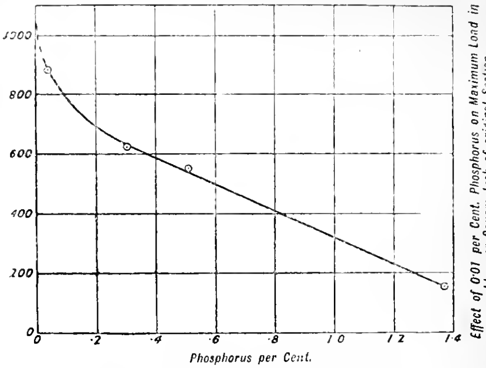



Fig. 3.—Effect of 0·01 per Cent. Phosphorus on Maximum Load in lbs. per square inch as deduced from Arnold's and Stead's results.

as distinct from the ladle sample. In Arnold's 1.29 per cent manganese steel the manganese adds 150 lbs. per unit to the tenacity.

It is interesting to apply the formula to some of the published lists of tests, so it has been applied to Harbord's basic Bessemer and basic open-hearth steels, as shown in Tables II. and III. In the mean of experimental and collected results, assuming 0.6 manganese and 0.5 phosphorus and silicon negligible, the carbon per cent recommended for 30 tons gives 30.8 by the formula; for 35 tons, 36.6; for 45 tons, 44.3; and for 50 tons, 49.6.

The agreement in the basic Bessemer series is quite good, the mean if the set by calculation being 33.8 and by test 34.1. The mean of those between 0.2 and 0.7 is still nearer, being 38.6 by calculation and 38.5 by

TABLE II.—*Harbord's Basic Bessemer Series.*

| Mark. | As Received. | Heated to 620° C. | Means of 2 and 3. | By Formula. | C. | Mn. | P. |
|---|---|---|---|---|---|---|---|
| 16 | 23·5 | 23·4 | 23·5 | 22·4 | 0·07 | 0·345 | 0·044 |
| 17 | 27·5 | 27·7 | 27 6 | 25·3 | 0·09 | 0·475 | 0·082 |
| 18 | 25·5 | 24·4 | 25·0 | 24·9 | 0·10 | 0·435 | 0·066 |
| 19 | 26·5 | 25·2 | 25·9 | 25·6 | 0·11 | 0·481 | 0·069 |
| 20 | 28·8 | 28·8 | 28·8 | 27·0 | 0·12 | 0·665 | 0·076 |
| 21 | 31·5 | 29·6 | 30·7 | 30·7 | 0·22 | 0·513 | 0·074 |
| 22 | 34·0 | 33·9 | 34 0 | 32·7 | 0·24 | 0·520 | 0 099 |
| 23 | 36·0 | 33·9 | 36·0 | 35·5 | 0·30 | 0·74 | 0·076 |
| 24 | 38·7 | 36·3 | 37·5 | 39·2 | 0·36 | 0·825 | 0·070 |
| 25 | 39·5 | 37·8 | 38·7 | 39·9 | 0·378 | 0·855 | 0·068 |
| 26 | 40·1 | 38·2 | 39·2 | 38·5 | 0·381 | 0·825 | 0·040 |
| 27 | 41 5 | 41·2 | 41·4 | 40·0 | 0·38 | 0·955 | 0·065 |
| 28 | 43·2 | 42·6 | 42·9 | 43·7 | 0·44 | 0·925 | 0·063 |
| 29 | 48 0 | 46·4 | 47·2 | 47·0 | 0·503 | 0·90 | 0·065 |
| Means | 34 6 | 33·5 | 34·1 | 33·8 | | | |

TABLE III.—*Harbord's Basic Open-Hearth Series.*

| Mark. | As Received. | Heated to 620° C. | Means of 2 and 3. | By Formula. | C. | Mn. | P. |
|---|---|---|---|---|---|---|---|
| 41 | 24·5 | 24·2 | 24·4 | 25·1 | 0·12 | 0·40 | 0·051 |
| 42 | 28·5 | 27 4 | 28 0 | 28·7 | 0·20 | 0·51 | 0·052 |
| 43 | 26·8 | 25·5 | 26·2 | 29·8 | 0 23 | 0·45 | 0·054 |
| 44 | 37·8 | 36·3 | 37·1 | 39·2 | 0·35 | 0·853 | 0·077 |
| 45 | 34·0 | 32·0 | 33·0 | 36·7 | 0·365 | 0·49 | 0·071 |
| 46 | 34·4 | 32·1 | 33·3 | 36·9 | 0·36 | 0 90 | 0·018 |
| 47 | 35 0 | 33·8 | 34·4 | 37·6 | 0·37 | 0·66 | 0·054 |
| 48 | 36·3 | 35·2 | 35·8 | 36·7 | 0·363 | 0·625 | 0·040 |
| 49 | 37·0 | 35·5 | 36·3 | 39·1 | 0·42 | 0·575 | 0·041 |
| 60 | 38·6 | 36·3 | 37·5 | 40·7 | 0 43 | 0 61 | 0·058 |
| 51 | 42·5 | 40·1 | 41·3 | 41·7 | 0·45 | 0·73 | 0·060 |
| 52 | 44·0 | 42 6 | 43·3 | 45·2 | 0·502 | 0·68 | 0·064 |
| 53 | 51·5 | 49·2 | 50·4 | 51·5 | 0·603 | 0·71 | 0·070 |
| Means | 36·2 | 34·7 | 35·5 | 37·6 | | | |

test. The agreement in the basic open-hearth series is not so good, the means being 37.6 tons by calculation and 35.5 by test. It would not be feasible to give the many hundreds of tests on which the calculations have been made, but a few have been gathered at random and are given in Table IV.

TABLE IV.—*Indian Basic Open-Hearth Steels.*

| No. | Section. | By Test. | By Formula. | C. | Si. | Mn. | P. |
|---|---|---|---|---|---|---|---|
| 1 | ¾ inch rd. | 23·5 | 23·5 | 0·13 | ... | 0·34 | 0·016 |
| 2 | 1 inch rd. | 26·1 | 25·3 | 0·14 | ... | 0·53 | 0·033 |
| 3 | ⅝ inch rd. | 26·4 | 25·5 | 0·17 | ... | 0·45 | 0·011 |
| 4 | 1 inch rd. | 26·8 | 26·5 | 0·18 | ... | 0·53 | 0·021 |
| 5 | 4 × ⅝ inch f. | 27·5 | 28·1 | 0·21 | ... | 0·69 | 0·00[illegible] |
| 6 | 10 × 5 b. | 28·2 | 28·0 | 0·22 | ... | 0·60 | 0·008 |
| 7 | 1½ inch rd. | 28·0 | 28·7 | 0·23 | ... | 0·57 | 0·016 |
| 8 | 1½ inch sq. | 28·4 | 34·0 | 0·25 | ... | 0·63 | 0·022 |
| 9 | ¾ inch rd. | 31·8 | 30·6 | 0·25 | ... | 0·64 | 0·030 |
| 10 | ¾ inch rd. | 31·8 | 31·4 | 0·26 | ... | 0·56 | 0·047 |
| 11 | 1 inch rd. | 32·3 | 31·6 | 0·27 | ... | 0·71 | 0·023 |
| 12 | 1 inch sq. | 29·1 | 29·3 | 0·28 | ... | 0·55 | 0·011 |
| 13 | ¾ inch sq. | 32·2 | 32·4 | 0·29 | ... | 0·74 | 0·015 |
| 14 | 10 × 5 b. | 34·4 | 34·1 | 0·30 | ... | 0·74 | 0·042 |
| 15 | ¾ inch rd. | 32·9 | 32·5 | 0·31 | ... | 0·56 | 0·017 |
| 16 | 10 × 5 b. | 35·3 | 35·6 | 0·32 | ... | 0·82 | 0·046 |
| 17 | 3¾ inch rd. | 36·5 | 34·8 | 0·34 | 0·06 | 0·66 | 0·018 |
| 18 | 1 inch sq. | 35·3 | 35·6 | 0·37 | ... | 0·66 | 0·010 |
| 19 | 1 inch sq. | 38·5 | 38·0 | 0·41 | ... | 0·66 | 0·015 |
| 20 | 5 inch rd. | 39.6 | 39·4 | 0·42 | 0·07 | 0·72 | 0·021 |
| 21 | 1 inch sq. | 37·6 | 38·9 | 0·44 | ... | 0·57 | 0·012 |
| 22 | 5 inch rd. | 40·9 | 41·8 | 0·44 | 0·08 | 0·82 | 0·010 |
| 23 | 5 inch rd. | 44·6 | 45·0 | 0·48 | 0·07 | 0·92 | 0·030 |
| 24 | { Imported basic rail } | 48·1 | 47·4 | 0·53 | 0·04 | 0·80 | 0·054 |
| 25 | 2 inches sq. | 45·5 | 47·9 | 0·57 | ... | 0·73 | 0·019 |
| 26 | ... | 54·5 | 55·2 | 0·66 | 0·15 | 0·75 | 0·046 |
| 27 | 1 inch oct. | 52·5 | 53·0 | 0·67 | 0·03 | 0·69 | 0·037 |
| 28 | ¾ inch rd. | N 54·0 | 54·0 | 0·69 | ... | 0·62 | 0·019 |
| 28 | ¾ inch rd. | N 54·5 | | | | | |
| 29 | ⅞ inch rd. | N 59·2 | 58·2 | 0·73 | ... | 0·67 | 0·029 |
| 30 | ⅞ inch rd. | 63·7 | 61·0 | 0·75 | 0·03 | 0·80 | 0·050 |
| 30 | ⅞ inch rd. | N 64·6 | | | | | |

Although the formula is intended for basic steel, it is worth applying it to acid steels to see the nature of the results. As an aid to inspection it has been helpful. Another of the causes that led to the search for a formula was the possibility of being able to distinguish between acid and basic steels by comparison of the test results with analyses of the test-pieces, as now, with high silicon alloys, simple analysis can no longer distinguish between steels made by the two processes. The author's Sheffield friends who long for a method that will enable the purchaser to know that he is getting acid steel, and our Middlesbrough friends, who are so proud of their basic steel that they would be shocked at any one mistaking it for acid, will be equally disappointed that in the lower and more usual tempers the differences do not seem to be sufficient to be quite characteristic.

In Table V. the results by the formula for basic steels on the acid Bessemer series of McWilliam and Barnes are shown, and for comparison those by the formula M.L. = 38,000 + 1,000 C + 200 Mn + 1,000 P, which is the formula for basic steels as it stands at 0.7 per cent carbon. The tenacity of steel (a) at 0.10 per cent carbon agrees with the basic steel formula, steel (b) with 0.27 per cent carbon agrees with values for carbon and manganese of 900 and 150 lbs. respectively, and the steels from 0.29 to 0.7 per cent carbon agree fairly well with the formula in column 6, whilst (b), the 0.75 per cent carbon steel, would require 1,100 lbs. per unit of carbon in the formula to agree with the test result.

In Table VI. are given Harbord's acid open-hearth series. All these steels, excepting Nos. 36 and 39, are within reasonable limits of those obtained by the formula. The only other series of acid open-hearth steels on which similar calculations have been made show similar results between those obtained by test and those by the formula for basic steels. There seems to be some real difference between the properties of acid Bessemer and acid open-hearth steels of the same composition, as ordinaily determined, and still more between acid Bessemer and basic open-hearth steels, but not so much between acid open-hearth and basic open-hearth, the cause of which has not yet been satisfactorily explained. H. H. Campbell, whose researches on similar formulae are so well known, remarks:[1] "The result indicate that the metalloids have different quantitative effects upon acid and basic steels. Now, if acid steel does not follow the same law as basic steel, then they are not the same, and if they are not the same, it is possible that one is better than the other, a possibility that is vigorously denied by some people."

TABLE V.—*Acid Bessemer Series of McWilliam and Barnes.*

| Mark. | As Received. | Normalised. | Means of 2 and 3. | By Formula for Basic Steels. | By 38,000 + 1000 C. + 200 Mn + 1000 P. | C. | Mn. | P. |
|---|---|---|---|---|---|---|---|---|
| a | 25·9 | 24·8 | 25·4 | 25·5 | 29·1 | 0·10 | 0·56 | 0·06 |
| b | 35·8 | 34·3 | 35·1 | 33·1 | 37·8 | 0·27 | 0·68 | 0·06 |
| c | 40·9 | 40·8 | 40·9 | 35·3 | 40·8 | 0·29 | 0·92 | 0·06 |
| d | 39·9 | 39·3 | 39·6 | 35·5 | 39·9 | 0·32 | 0·67 | 0·06 |
| e | 46·6 | 48·1 | 47·4 | 42·3 | 47·3 | 0·44 | 0·90 | 0·06 |
| f | 52·2 | 52·3 | 52·3 | 46·8 | 50·2 | 0·50 | 0·92 | 0·06 |
| g | 59·0 | 59·4 | 59·2 | 58·9 | 58·9 | 0·70 | 0·90 | 0·06 |
| h | 64·2 | 65·4 | 64·8 | 62·4 | 61·3 | 0·75 | 0·92 | 0·06 |

## Summary.

On the publication of Dr. Stead's paper in September, 1916, the author felt that as a contribution to the attempt to determine more and more closely the influence of each of the elements on steel it would be worth preparing for publication his own results which he had obtained as a help in his ordinary work as well as for their metallurgical interest. All these formulae should have as their constant the strength pure iron. The formula used at present for sections that would give results near to those obtained on 1 inch round bars normalized is given with a table of the effect of carbon between 0.1 and 0.75 for ease in calculation. The results of the application of the formula to certain series of steels are shown.

TABLE VI.—*Harbord's Acid Open-Hearth Series.*

| Mark | As Received. | Heated to [illegible]° C. | Means of 2 and 3. | By Formula for Basic Steels. | By 38,000 + 1000 C + 200 Mn + 1000 P. | C. | Si. | Mn. | P. |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 25·5 | [illegible] | 25·5 | 25·6 | ... | 0·132 | 0·03 | 0·466 | 0·05 |
| 31 | 26·2 | 26·8 | [illegible] | 26·1 | ... | 0·126 | 0·02 | 0·53 | 0·058 |
| 32 | 30·3 | 30·2 | 30·2 | 29·1 | ... | 0·183 | 0·04 | 0·71 | 0·052 |
| 33 | [illegible] | 33·1 | [illegible] | 34·3 | ... | 0·211 | 0·02 | 0·575 | 0·052 |
| 34 | 37·0 | 37·6 | 35·3 | 37·7 | ... | 0·370 | 0·06 | 0·80 | 0·029 |
| 35 | [illegible] | 41·7 | 42·7 | 41·1 | ... | 0·436 | 0·04 | 0·71 | 0·041 |
| 36 | 49·5 | 43·7 | 46·6 | 41·7 | 44·7 | 0·45 | 0·07 | 0·68 | 0·058 |
| 37 | 46·8 | 44·1 | [illegible] | [illegible] | 47·1 | 0·50 | 0·05 | 0·672 | 0·041 |
| 38 | 50·4 | [illegible] | 49·2 | [illegible] | [illegible] | 0·57 | 0·05 | 0·71 | 0·047 |
| 39 | 60·8 | [illegible] | 53·6 | [illegible] | 55·2 | 0·66 | 0·05 | 0·70 | 0·055 |
| 40 | 55·7 | 52·2 | [illegible] | [illegible] | [illegible] | 0·67 | [illegible] | 0·60 | 0·054 |

A bibliography on the influence of some elements on the mechanical properties of steels was given by Dr. Stead in September, 1916. The papers by McWilliam and Barnes on Heat Treatment were included, excepting the one on "A Heat Treatment Study of Bessemer Steels," to which it is well that students should refer, as it shows what can be done with first-class English acid Bessemer steels, for comparison with results on more costly material.

[1] "Manufacture and properties of iron and steel," p. 23.

## NOTES FROM BRITISH COLUMBIA.

Darwin and Milner, Steel Manufacturers, of Sheffield, England, are closing their branch office in Vancouver, due to the impossibility of obtaining supplies. Mr. L. C. Schuthe, Vancouver manager, will leave for Sheffield in order to study the process used in producing the "cobalt chrome high-speed steel," a recent invention of the principals of the firm, which is made without the use of tungsten. Mr. Schuthe, after studying the process in England, will go to Pennsylvania in order to instruct the Darwin & Milner plants there, in its use.

---

Mayor Vance, of North Vancouver, is a persistent advocate of steel production in British Columbia, and recently stated that it is his intention to "stay with the plan and push it to a successful conclusion."

---

The Pacific Coast Smelting Co., are reported to have made successful tests in the smelting of iron ores by electricity, and it is said will erect a battery of furnaces near New Westminster, B.C.

---

An electric smelting works of considerable importance to the Province of B. C. is now under construction in the heart of Vancouver City by The Tudhope Electric Metals Co., Ltd., who are installing the most improved type of plant using high voltage electricity.

The works are designed for a considerable output, and marks a new era towards establishing a steel industry in B.C., on a solid and permanent basis. Several of Mr. Tudhope's technical staff have already arrived from Eastern Canada, and the plant is expected to be in full operation almost immediately. The works have been built in a remarkably short period, and will give continuous employment to a large number of hands henceforth.

---

It is rumoured that the Federal Government is contemplating the construction of steel ships on Vancouver Island, in the vicinity of Nanaimo, B.C.

---

Making a Canadian record for rapid construction, J. Coughlan & Sons, Vancouver, B.C., Saturday, Sept. 28th, launched their fifth steel vessel, the War Noble, sixty-three working days after laying the keel.

This boat, like the Alaska, War Camp, War Charger and War Chief, is a freighter of 8,800 tons dead weight, 427 feet long, 54 feet beam, 29 feet 9 inches deep.

---

The 4,800 ton steel freighter, War Storm, was launched at Wallace Shipyards, North Vancouver, B.C., Saturday, Sept. 28th. This is the third steel vessel from the Wallace Shipyards.

---

The largest Scotch marine boilers built so far in Canada are in course of construction on the Pacific Coast by the Vulcan Iron Works, of Vancouver, B.C.

These boilers have a diameter of 15ft. 6in. by 11ft. 3in., and weigh 55 tons. Several are being built, and all of them will go into steel freighters built in British Columbia.

According to reliable information the largest previous boilers of this class constructed in Canada were 14ft. 9in. in diameter.

## STEEL INDUSTRY IN WESTERN CANADA.

At the time of writing the position of steel and of steel tools and supplies, so far as Western Canada is concerned, is still one of very great difficulty, and practically no relief for the future is in sight; indeed the position is becoming more complex all the time, and markets are now practically cleared of certain sizes and sections. In the matter of heavies (ship plates, etc.), these are coming forward from the Eastern mills on government permits, that is to say, for international purposes, and the difficulty here is one of transportation owing to the shortage of cars, especially in the United States. However, the Western ship-building plants are obtaining the requisite material under the conditions stated above.

With regard to the lighter material—tool and mining steels, steel tools, etc.—the difficulty of obtaining supplies is most acute. For some considerable time there has been an embargo on the export of steel and steel tools from Great Britain, with the result that Western stocks are coming down almost to the vanishing point. In these circumstances the American manufacturers and merchants are pushing the Westen Canadian market hard, and it will be a difficult matter for the British makers, more especially the Sheffield manufacturers of steel, to recover the footing they had obtained in this market previous to the war. We have had the unique experience of seeing high speed tool steel (mostly used on machining tools) touch $3 to $4 per pound, which material, previous to the war, ranged in the neighborhood of 50 to 75c. per pound. A good class of tool steel, which sold on the Western Canadian market at the pre-war price of 12 to 14 cents, is now making at least 25 cents per pound in Sheffield, England, and other grades have made similar advances. On tools, such as files, hacksaws, twist drills, etc., the advances on pre-war prices have been fully 100 per cent., and in some cases more, and supplies are most difficult to obtain. In fact, from a steel manufacturers' point of view, the problem is not one of obtaining business, but of supplying the demand.

Iron and steel are the most vital necessities of a country, and are certainly the life-blood of industrial progress. When we and our Allies have at last beaten German militarism, the victory will be, in a large measure, due to the capacity of Sheffield steel works, and the superior qualities of Sheffield steel products.

Roughly speaking, there are three processes for producing steel—the Bessemer, the open hearth, and, latterly, the electric furnace. The Bessemer or pneumatic method of turning iron into steel was found by experimenting, and depends on the discovery that molten iron could have its heat intensified, its impurities eliminated, and could be converted into strong, malleable, uniform and homogeneous steel by the simple process of forcing minute streams of cold air through it.

By this discovery, which was made by Bessemer in 1856, pig iron, worth at that time roughly $35 per ton, was converted into steel worth (at that time) $350 per ton. The Bessemer process enabled steel to be made far more cheaply than in the past, and almost immediately made it possible to build ships and make rails, etc., with this new kind of steel. This invention, was, and still stands, "the greatest metallurgical discovery of the age."

It would be interesting to know how far the matter of iron and steel production in British Columbia is progressing, and if any results have followed the visit of the British Columbia delegation to Ottawa on this subject. What is to hinder capital from becoming interested in the manufacture of iron and steel in British Columbia? Surely it is possible to make a test production of steel from the natural deposits of ore, coking coal, etc., in this province, and thus to secure reliable data with regard to these deposits, and the conditions governing steel production, so that we could inform intending capital with regard to the approximate cost of producing steel in this province.

With regard to the market in Western Canada, let us not base our calculations on the present consumption, but rather have faith in the future, as I am assured, with the advent of iron and steel production in British Columbia, a hundred allied industries would spring up from this "parent" supply. While it would be too ambitious to hope to compete with Pittsburgh in the "heavies," where the rolling mills, etc., are running full blast day and night throughout the year, and where the big corporations think nothing of scrapping vast equipment, having at their command a world-wide outlet for the finished material, yet we would have fully all we could do to look after the demands in Western Canada, of the new industries that would spring up, such as iron and steel founding, including the making of castings for all parts of shipbuilding, machinery manufacturing, car-building and many other industries, not even overlooking the manufacturing of smaller tools.

GEORGE LOCKHART SCHUTHE.

## HAMILTON NOTES.

A joint meeting of the Toronto Section of the American Institute of Electrical Engineers and the Hamilton Branch of the Engineering Institute of Canada had been arranged to be held in the Westinghouse Auditorium, in the Westinghouse Co.'s new office building. Mr. G. E. Stolz, of the Westinghouse Electric & Manufacturing Co., Pittsburg, was to have given an address on "The Electrification of Steel Mills." The meeting was arranged for Friday, October 18th, with inspection trips to some of the Hamilton plants on the following morning. Owing, however, to the serious outbreak of Spanish influenza the meeting and trips have been postponed.

To provide suitable accommodation for their employees at a time when houses are so scarce and expensive, the Brantford Steel Products Co., Ltd., have plans, that are rapidly being put into execution, for building a small model village in the vicinity of their works. In Lansdowne Park, a very desirable location, a number of houses are already nearing completion and others are under construction. The company's plans provide for the erection of one hundred houses at a cost of about four thousand dollars each, and arrangements have been made to sell to the workmen at cost. The houses are of seven distinct types, and will be comfortable and up-to-date in every way. There is plenty of room in the locality so that there need not be any monotonous similarity in the design. The lots will not be smaller than about forty feet by a hundred and fifty, and the houses are to be of seven rooms.

This company is at present engaged on large war orders, but expects to organize as a permanent industrial concern when peace comes. Last spring two extremely handsome new buildings were completed and put into operation by the company which has a very fine plant and has grown very rapidly of late.

The Oliver Chilled Plow Works of Canada, Ltd., has about completed a new oil tank for the storage of fuel oil. The tank has a capacity of about 132,000 gallons.

Nearly all the heating furnaces in the forge, etc., are oil heated, and although the company have sufficient storage capacity for normal times, the new tank has been erected to take care of shipping troubles, etc., through the winter.

The Hamilton Bridge Works, Co. Ltd., are installing an additional 20,000 gallon oil tank to take care of possible troubles and traffic tie-ups through the winter. They have at the present time two large furnaces and a number of small ones heated by oil, while a third large furnace similar to the others is under construction. The company has three oil storage tanks at present in operation and though these are sufficient in normal times to take care of all their furnaces, it has been felt wise to put up an additional tank to provide for emergencies.

The Steel Company of Canada has decided to install a benzol building in connection with their new coke ovens. The building will be at a distance from the other bye-product buildings, and will be entirely enclosed by a 12ft. brick wall. Work is being pushed on both the foundations and structural steel work.

John Bertram and Sons, Ltd., of Dundas, are putting up a heat treating building, about 60 by 120 ft. The Hamilton Bridge Works Co., Ltd., have the contract for the structural steel work on the building.

The Dominion Foundries and Steel Co. recently wrote the City of Hamilton stating that a few days previously they had been refused consideration on a large contract because sufficient electric power was not available in Hamilton. The Company pointed out that the industrial growth of Hamilton was being stunted on account of lack of power.

A charge was made recently that Hamilton had been discriminated against in the matter of power supply by the Hydro Commission. A deputation went to Toronto a short time ago to take up the matter with the Hydro Commission. It was pointed out that the National Abrasive Co. had recently moved their plant from this city at a very heavy loss on account of their inability to obtain a sufficient power supply. Other points were brought up and it was asked that the complaints should be put in writing.

It is hoped that very shortly some additional power will be available from the Chippewa Creek Development, but in the meantime power conditions in the city are getting more and more acute.

A few days ago The Hamilton Hydro Electric Commission requested its customers to reduce, if possible, their power load by twenty per cent. The Cataract Power Co. are able to supply a certain amount of extra power, but the outlook for consumers at present is very serious.

It is hoped that the first unit of the new coke ovens for the Steel Co. of Canada will be put in operation by about the 15th of November.

Spanish influenza has been raging in the city nearly all through October. There have been a number of deaths and many of the industries have been short handed, although the epidemic does not seem to have hit Hamilton as hard as many other cities. It is hoped that the epidemic is now being brought under control, and that the number of cases will soon decrease rapidly.

---

The first unit of the new technical school is progressing rapidly; the second floor is about ready to pour, and the work is being pushed along steadily. The new building, which is located on Wentworth St. N., is of reinforced concrete construction. Very recently the Government made a grant of $175,000 for a second unit to be used for educational purposes for returned soldiers.

When the unit is no longer needed for this purpose it will be turned over to the city as part of the regular technical school.

Mr. Sprague, the principal, expects to organize the three units together as soon as they are ready for use.

Work has not been commenced on the third unit of the school, but it is expected that a start will be made very soon. W. H. Yates, Jr., is contractor for the second unit.

---

Mr. Fred Kirkpatrick, who for some time has been Master Mechanic at the East End Plant of the Hamilton Bridge Works Co., Ltd., has left the service of that company to accept a position in similar work with the London Technical School.

Mr. Kirkpatrick's cousin holds a similar position with the Hamilton Technical School, and his brother is Commissioner of Industrial for the city of Hamilton.

---

The handsome new office building for the Steel Co. of Canada is progressing rapidly, and will be a great credit to the company. Prack and Perrine are the architects and are looking after the construction work.

---

## MONTREAL METALLURGICAL ASSOCIATION.

The meeting arranged for October 8th, but postponed on account of the influenza, will probably be held on Tuesday, the 19th of November. The subject is a discussion of the meaning of "The Critical Points" in steel, and this will be illustrated by experiments and lantern slides.

---

## MACHINERY FOR SALE.

Air compressor for sale—One vertical steam-drivn air compressor, steam cylinders 18"; 36" by 36" stroke, air cylinders mounted immediately above, 18" and 31" diameter; capacity about 2,000 cu. ft. of free air per minute, air pressure in the mains 100 lbs.; engine designed for 130 lbs. steam pressure; is now running and in good working order, and can be seen at the plant of the Collingwood Shipbuilding Co., Ltd., Collingwood, Ont.

# The Allied Metals Congress

The Allied Metals Congress at Milwaukee was held from October 7 to 11, under the joint auspices of the American Institute of Mining Engineers, the American Foundrymen's Association and the American Malleable Castings Association, and was a meeting of unusual importance. Its purpose was to assist in carrying on the war, and those who organized the Congress and all who contributed to make it a success have good reason to believe that their efforts will have good results. Many valuable papers were presented and discussed, and a splendid exhibit was made of labor-saving machinery. Those who attended must have profited by the many practical suggestions that were offered and have been stimulated to greater effort by the earnestness of purpose of their fellows. Men who are responsible for the production and manufacture of metals have seldom gathered in such numbers anywhere in America; certainly never with so serious a common object. Not under ordinary circumstances will one see eight hundred foundrymen listening with rapt attention to technical descriptions of processes of manufacturing cast iron.

Headquarters for the Congress were at the Milwaukee Auditorium. This splendid building is exceptionally well adapted both for exhibitors and for meetings. The hundred and sixty-five exhibitors had space in the Arena and Machinery Hall. In the latter were manufactured products, tools, shop supplies, and accessories; in the former, foundry and metal working equipment was shown in operation. Large and small lecture halls were utilized for the meetings.

Opportunity was given to visit many of the notable plants in Milwaukee and vicinity. A schedule was arranged and private cars took the guests to the plants of the Allis-Chalmers Mfg. Co., Kearney & Trecker Co., Falk Co., Chicago & Milwaukee Ry. Co., Wisconsin Gun Co., Sivyer Steel Casting Co., Pawling & Harnishfeger Co., Northwestern Malleable Iron Co., Vilter Mfg. Co., and the Filer & Stowell Co. The great shops of the Allis-Chalmers Co., the Falk Foundry and the Wisconsin Gun Co., where 75 mm. guns are being made, proved particularly interesting to many of the guests.

At the opening session the Hon. E. L. Phillipp, Governor of Wisconsin, welcomed the guests. He dwelt on the need of materials for carrying on the war, and asked those present to proceed with their plans for increasing production regardless of rumors of peace. He believed that the end of the war is drawing near, but he thought it very important that there should be no halt in production until peace is an accomplished fact. He ventured the opinion that when peace does come there will be a tremendous demand for materials for reconstruction. Mr. B. D. Fuller, president of the American Foundrymen's Association assured him that the foundrymen would not allow peace talk to interfere with their efforts. He congratulated Milwaukee.

Mr. E. D. Brigham, manager of the iron ore, coal and grain traffic of the United States railroad administration, asked for the co-operation of the metal trade in meeting the demands made on transportation. He said that everything must be subordinated to the demands of the government and that producers must look with patience on shortage of shipping facilities.

Mr. C. S. Koch, of the Ordnance Department, Washington, gave some account of the activities of the Army Ordnance Department, with especial reference to foundry matters. Major Frank B. Gilbraith gave an illustrated talk on military matters of special interest to metal workers.

It was decided that a message should be sent to President Wilson assuring him that the metal industry would leave nothing undone to accelerate the production of munitions. The following resolution was passed:

"That every resource of these allied metal trades is again pledged to the government not only in the production of materials for the conduct of the war, but for the accelerated manufacture of these materials to enable the government to greatly intensify its prosecution of the war and to bring about a speedy and crushing defeat of the enemy that will lead to his abject and unconditional surrender."

The opening session was a joint one; after its conclusion the several sections held separate session. Many technical paper were presented. Some of which have been already published and others will be available at an early date. We have not space in this issue to give a list of the papers.

While the Congress was in session a message was received from Chairman Hurley of the United States Shipping Board who urged manufacturers to increase their export trade. He said that the U. S. Government was turning out many ships that would be of little use after the war unless manufacturers took advantage of the favorable opportunity for increased export of goods. Chairman Hurley asked for committees to investigate the situation.

One of the notable features of the Congress was the session devoted to manufacture of semi-steel. The opinion was expressed on all sides that semi-steel shells will soon be manufactured in very large quantities in the United States, as they have been in France. In view of this fact the manufacturers who have facilities for undertaking the work took a very keen interest in whatever information was obtainable at the sessions.

The chairman, Mr. John A. Penton, opened the session by a short address in which he pointed out that it was expected that many of those present would be called upon to make semi-steel shells. He asked them to follow carefully what was said concerning the manufacture and to consider whether they could undertake such work. He believed that many plants would be found suitable for the manufacture of such shells. The chairman then introduced three French Army officers, members of the Commission now in Washington.

The experience of the French manufacturers of semi-steel was outlined by Lieut. Laurent. He stated that some semi-steel shells had been made before the war and the invasion of Northern France had made it imperative that a substitute for steel be found. The French Ordnance Department found this substitute in cast iron of the variety known as semi-steel.

The ordinary cast iron shell had not sufficient strength and gave on explosion a comparatively small number of effective fragments. When steel scrap is added to the iron, however, a low carbon iron is ob-

# EDITORIAL

## THE PEACE.

The eleventh of November, the day on which the armistice with Germany was signed, marked a complete change in the mental attitude of the whole civilized world. Before that day our thought was directed, almost entirely, to the problem of winning the war. Now we are wondering what kind of a peace we can obtain and what preparations we should make in view of the change from war to peace.

The war has shaken up, very considerably, the state of society that existed before 1914, and we are faced at present with an unique opportunity for carrying out many desirable reforms, and also with a serious danger that certain undesirable changes may take place. The very best thought and judgment are needed at present if we are to secure the good and escape the bad, and every patriotic citizen should do his part towards this end. The peace that we seek does not depend alone on the terms to be laid down at the Peace Conference in France, but to an even greater extent upon the establishment of equitable and satisfactory relationships between the classes of society within each nation.

Speaking generally, we know that valuable results are achieved by co-operation, not by discord and strife. The war has made this clearer to us than ever before. The army conquered the enemy by the united effort of all the soldiers and officers who worked together with harmony and discipline to obtain that object. The nation won the war because the citizens, as well as the soldiers had one end in view and subordinated their private affairs to the one business of winning the war. The Allies won the war because they co-operated in every way to that result, each nation contributed whatever it had—money—men—ships—provisions, without bargaining or thought of the separate aims or ambitions of each; and because ultimately each nation contributed its army to form a part of a whole; England, America, Canada, Italy, surrendered the supreme command of their armies to a foreigner.

Now that the war is over, must all this cease? Have we now no all-compelling aim that over-rides our private interests? Must the idea of each be merely to get all that he can, regardless of the others, and the Devil take the hindermost? Must we now abandon all that we have learnt of the value of co-operation and discipline?

The world to-day is a complex society in which each individual depends on many for the necessities of his existence. No one can live to himself, and the welfare of the community depends upon the co-operation of its members. In the past we were told that business was business; that each manufacturer was justified in any action, not specifically illegal, which gave him a larger profit, and that each workman was justified in any action by strikes or otherwise, which enabled him to get a larger wage. One of the most valuable lessons we have learnt during the war is that this point of view is incorrect: the manufacturers and the workmen are servants of the public: their business is to supply the public with honest and satisfactory goods at a reasonable price: the personal reward that they receive for these services, although important, must be secondary to the services themselves. This condition, which is essential for satisfactory life in a society; depends upon harmony among the three—the business man, the workman and the public. The peace that we seek for the twentieth century must be a peace between the classes in society as well as between the nations.

In the past we were told that competition is the only possible rule in life. We understood that the struggle for existence and the survival of the fittest had led in the past to the progress of the race, and we were told that a struggle for existence, in which each is allowed to get and retain as much as he can, is the only condition on which further progress can be made. Even the wild animals, however, do not live in a condition of unrestricted competition: herds of animals co-operate for their defence and in other ways, and, in human affairs, as we ascend the scale of civilization, co-operation becomes increasingly essential and enmity between individuals or classes becomes increasingly injurious, both to the individual and the society.

Peace is not merely the absence of warfare: had Belgium permitted German armies to march through without opposition, that would not have been peace. In the same way peace in a society does not mean merely the absence of hostilities: if the workmen are oppressed by the capitalists, or the manufacturers are hindered by unfair restrictions of the labour unions, or if the public is fleeced by a combination of capital and labour, there is no real peace. The peace that we need, and the peace that we must all work for; can only be based on justice and honesty between the different classes of society and the different individuals of each class.

When we try to ascertain what is justice, as between individuals and classes, we are met by serious difficulties, and it appears impossible, from the nature of the case, to arrive at any complete solution, but there are some general principles that will serve as guides in the working out of the specific problems that present themselves. In Russia, the working classes, long oppressed by the nobility and the business men, considered that the upper classes were unnecessary, and, being themselves in the majority, proceeded to exterminate their former masters. Leaving on one side all question in regard to the ethics of extermination, we realise that our modern civilized society offers greater possibilities for the average individual than a primitive society from which all educated people had been removed. Bolshevism, or the oppression of society by the least educated classes, is certainly not the peace that we need.

An ideal society cannot be attained until the individuals composing it are perfect, but we need not despair of effecting a decided improvement even with human nature as we find it to-day. An improvement in the society will cause an improvement in the individual, and in this way important changes for the better may ultimately be made. The point we wish to emphasise is that in working for peace in the community we must keep in mind the lessons we have learnt in the war: the duty of each individual towards the whole; co-operation to a common end, instead of conflict and strife, and submission of the individual to discipline, which is necessary for united and effective action.

The Englishman, and his descendant on this side of the Atlantic, has always prided himself on his individual liberty, and this attitude has been of the greatest importance at certain stages of the national history. In the army, however, each soldier places himself absolutely under the command of his superior officer, and we realize that submission of the individual to discipline is essential if we are to obtain real freedom. In the past, the policy of British Governments has been to interfere as little as possible with the individual freedom of the citizen. We have realised, however, even in the past, that this policy of "laissez faire" had been carried too far, and that a larger measure of Governmental control was necessary for the satisfactory conduct of a complex society. In the past the Government was afraid of taking further responsibility and the citizen was jealous of surrendering his historic rights of individual action. The war has made a profound change in the situation. The Government has become accustomed to control the citizen in the conduct of his business, and even in the details of his daily life, and the citizen has submitted; realising that the control was exercised for the common good. A beginning has thus been made, and the way opened for such action as may ultimately be found necessary to obtain the effective co-operation of the citizens in the service of society as a whole, and to secure to each his rightful share in the necessaries and comforts of life. We recognise that the action of Governments is not always beneficial; we have been afraid of the continuation, in peace times, of a control which, while annoying to the individual, was rendered necessary by the urgency of the war; we realise the importance of individual freedom and initiative, and the danger of this being stifled by too much legislation; and yet, with all these dangers, we believe that the co-operation of all is so essential to a satisfactory social life, that we cannot now return to the condition of unrestricted competition which obtained in the past, and that a more complete organization of society will be essential to that peace which we hope will crown the years of war.

## STEEL INSPECTION.

Superficially it would appear as a self-evident fact that simple laws should control the inspection of steel, and, given qualified inspectors, such would be the case. There are two sides to the question and each can be defined in simple terms: the manufacturer should supply what the specification calls for, and the inspector should accept nothing that is not up to the required standard. The history of steel inspection in Canada may be divided into three phases: before the war it was not usual to call for any closely specified chemical content, the custom being to ascertain whether a casting was sound, of reasonably good appearance, and suitable for the purpose for which it was made. Then came munition specifications demanding a chemical composition within certain specified limits, together with ability to withstand the necessary physical tests. Those in authority were then faced with the problem of finding men qualified to handle the physical inspection end, both as regards the raw—as cast—blank, and the regulation test piece. The demand for this class of men created a supply of "qualified" steel inspectors that was appalling in its magnitude, and amongst upwards of a thousand of these the majority laid claim to special knowledge, and were aggressively anxious to demonstrate this fact under any and all circumstances. An analysis of the credentials of some few of these men disclosed strange facts, and it was almost impossible to find a trade or calling which, according to some men, was not a fit training for an inspector of steel. The old medley of—

"*Tinkers, tailors, soldiers, sailors.*"

was far short of being comprehensive enough to cover the daily avocations of these men prior to their undertaking the duties of steel inspectors. We know of innumerable cases where examiners, after a few weeks' work, knew more about structure, pipe, blows, segregation, etc., than other men had been able to grasp after years of close study and experience. We shall show how this superficial "knowledge" operated detrimentally to the interests of the steel producer without acting as a safeguard for those firing the shells. As an indication of the methods employed we may outline the organization in a given plant and show the farcical na-

ture of some men's duties and their absolute ignorance of the operations they were supposed to control. It was usual to place one man on the open-hearth platform to check up the charging, working, and tapping of a heat and his duty was to see that everything was done in accordance with modern practice. When one considers the fact that few of these men ever had been near an open-hearth furnace prior to accepting the responsibility of checking steel making operations, one ceases to wonder at some of their actions. We have known men who have objected to, and reported upon, every detail of modern steel making practice, and Ottawa must have the most wonderful set of reports if all such records have been retained. Upon one occasion it was reported that some addition was made to the molten steel after it was tapped into the ladle, that the inspector could not discover the nature of this material, and that the steel makers refused to discontinue the practice after notice had been given. The report asked for instructions as to how the inspector was to proceed? The addition happened to be the usual amount of ferro-silicon which must necessarily be added to the ladle and not to the bath, in basic practice. Then the examiners, whose duty it was to inspect the clean fracture after the removal of the discard were obsessed with an isolated idea, simple in its conception, comprehensive in its action, but fatal as regards production. This one idea was to reject blanks, then more blanks, and then still more blanks, and after that, like the Village Blacksmith, they could say:

*"Something attempted, something done,*
*Has earned a night's repose."*

Some world renowned metallurgists and metallographers would give almost anything to possess the intuitive knowledge exhibited by some of these men who in days, weeks, or months, as the case might be, had learned how to detect all faults possible to crude cast steel. Sometimes reasons were assigned for rejection, and a diagnosis of disease given that ought to have made Tubal Cain turn in his grave. Sulphide and phosphide segregations, usually requiring the aid of microscopical investigation, were easily apparent to some of the metallurgical wizards. If a primary pipe was not apparent, it was safe to assume the existance of a secondary one: or if two blanks exposed different crystal size, then the steel was certainly wrong, such a condition, according to some examiners, could not have been produced by different pouring temperatures, although the steel maker always looks for this varying size of crystal development in big heats. The great test, however, was that depending upon a pin, if by coaxing, or slight physical manipulation, an ordinary pin could be made to stand up, then assuredly that steel was "piped" and must be rejected. We have seen (and still retain a photographic illustration) a case where in breaking-off two crystals had been partially torn away, but remained attached to the blank, a pin was tried at the juncture of these two crystals, stood up, and of course, the blank was rejected as piped. In this particular case the so-called "pipe" was 1¼ inches off the centre of a six-inch blank, and no unequal cooling, likely to draw the pipe away from the centre, could be discovered when the discard was split and examined. The antagonistic attitude of individuals must surely have arisen from some mental twist very hard to explain, but none-the-less harmful to all concerned. Quite recently an "inspector" (who is a photographer by calling), issued a notice in which he strongly condemned the friendly interchange of civilities between his subordinates and the officials of the firm where 9.2-inch shell blanks were being made, and insisted that all such conduct must cease. The inference was either that he lacked confidence in his own men, or feared the interference of the officials. If this man had been experienced; if he had studied human nature at all; or if he could have realized that harmonious working was essential to maximum production, such a notice would never have been issued. This is only one case of many that could be cited, but Montreal manufacturers know from bitter and costly experience that men who should have been interested and anxious for maximum production were jubilant when from any cause whatever they were able to reject steel, or steel products. Perhaps the reiteration of these facts may seem somewhat akin to flogging a "dead horse," but if they help forward the essential knowledge that Canadian steel makers are not, and never were, anxious to avoid legitimate inspection, their publication will not have been in vain. All must realize that inspection is a necessity and endeavor to so conform to specification requirements as to avoid having the steel product rejected. Educational facilities are not wanting in Canada, and manufacturers should present a bold front, and firmly refuse to tender for the manufacture of steel products, unless the same are to be inspected by men educated in the business and possessing judgment capable of interpreting clauses in a specification. Personally we have seen steel worth hundreds of thousands of dollars turned down and scrapped for imaginary defects by men who were unable to assign any valid reason for their action, and the maker had no real redress. If a local examiner's decision was objected to, one could appeal to others higher up, and wait patiently whilst the complaint wandered from man to man, and office to office. After the lapse of varying periods of time, one, two, three, and sometimes four, officials would arrive from Ottawa, to investigate. A short time spent at the plant would generally elicit the statement that the matter would be considered, and then at some later period would come an official letter notifying the complainants that the original verdict was upheld, and therefore the steel must be scrapped. The net result was the manufacturer had lost his steel, his time, his money, and perhaps a certain portion of his temper, with probably quite a number of mental black marks recorded against him. Of course,

it could only be coincidence, but quite frequently after a complaint had been made the rejections became much heavier for some subsequent period. Whilst firmly of the opinion that the Canadian steel makers, as a class, were honestly endeavouring to supply a metal in every way satisfactory, it has to be acknowledged that the inspection was crude, ignorant, and grossly unjust in many cases. But the reiteration of almost unbelievable details is stale, flat and unprofitable, and it is better to pass from the tragedy of steel inspection during the four years period of the war to a consideration of the future aspect of the question. Wherever steel is made, whether by crucible, Bessemer, open-hearth, or electric methods, clear, definite and unambiguous specifications must be drawn up, and their conditions interpreted by men of common-sense and experience, and who possess intelligent knowledge of steel. The wrongly conceived idea of antagonism between producer and inspector must be abolished; and the introduction of better feelings will be conducive to a higher standard of working conditions, to a better class of product, and will help to erase the memory of errors, indiscretions, and unnecessary losses left behind by "steel inspection" during the war.

## OUR ADDRESS.

Iron and Steel of Canada is now printed in the new home of the Industrial Press at Ste. Anne de Bellevue. All contributions should be addressed to the Editor-in-Chief, Dr. Alfred Stansfield, at McGill University, Montreal.

Mr. John S. MacLean, Advertising Manager of the Canadian General Electric Company, and also of the Canadian Allis-Chalmers, for the past five years, has resigned.

## EQUIPMENT.

By M. E. WELD.

The cessation of hostilities will turn capital from "War Babies" to productive channels and the investor of capital will be guided partly by the advice of friends, partly by his own observations. To aid such investors, the following article is being placed before you in the hope that due consideration be given the advice and in order that intelligent observation may be made.

From a careful study of numerous manufacturing plants in Canada and the United States, the first thing that strikes the trained mind, is the poor layout of the plant and undesirable location. This is excusable in a plant started for the production of a certain article, and then added to from time to time as increased production, or other fields of work, may demand. No possible reason exists, except lack of knowledge, why plants planned today should not be designed for economic operation and provision for future extensions provided.

Manufacturing, to be successful, has a few vital points that must be kept in mind:

1st—Suitable location;
2nd—Economic production layout;
3rd—Facilities of transportation.

There are plants in operation today where the location is not suitable for the purpose intended, there are plants planned to build ships a mile or more away from navigable waters and steel foundries, without direct rail or water connections. To be successful a plant should be located on or close to unlimited water, and served by competitive railway systems; a plant so situated would have a suitable location and materials shipped to and from the plant at a minimum freight rate.

If there is a property of several acres, the buildings should be placed a reasonable distance from the highway, labor should be able to go to and from work without wading through six feet of snow in a zero temperature. Labour, the most important feature in manufacturing, is the most neglected, and as skilled and unskilled labor will be the main factor in costs, it is necessary to provide facilities for their comfort. The housing of labor where plants are distant from large cities is suggested, as with proper supervision it can be made productive. Nature follows the lines of least resistance, and the almighty dollar is only too eager to do the same, as is only too apparent when dividend time comes with industries badly situated, buildings poorly located and labor ignored.

Books have been, are being and will be written regarding "Economic Production"—usually based on shop costs only, the plant layout not being taken into consideration. Plant layouts are more often wrong than right, with the result that labor is underpaid and conditions of manufacture rendered unhealthy in an endeavour to obtain Economic Production.

Economic Production demands buildings properly lighted, ventilated and machines placed to prevent output going over the same road twice. The building themselves must be so situated on property that supervision can be easily controlled and where the units producing can be transferred with minimum expenditure to the point of assembly.

There are plants operating with the "Power House" so located that coal, as received, is carted to a coal pile and re-carted as required, adding at least one dollar per ton to all fuel consumed, this condition does not require further comment.

While on the subject of "Power Houses"—the heart of an industry—not being a producer, has always had the least consideration. The average conception of a "Power House" is—that it is somewhere that coal is burnt or electric energy distributed. The consequence is, that any old place will do for its location, and any old machine that will turn, is good enough—the result is always the same—the stack produces a beautiful black smoke—meaning wasted heat units and the machines are usually out of business when particularly required.

A Power House should be properly located, and designed; kept clean, main units should be in duplicate or if initial expenditure does not allow of duplication when starting—provision should be made in original design. The space, provided for a power house, should permit of at least 100 per cent increase in capacity without the necessity of changing adjacent buildings.

The detail of a Power House will not be gone into, as the subject is too wide for this article, but the best talent should be obtained to go thoroughly into the whole design to prevent costly errors before construction begins.

Equipment of buildings is too extensive to enter into, but, the Equipment of Staff from president to rivet boy should have an investors consideration.

A silk purse cannot be made from a sow's ear, neither will an office man make a satisfactory shop superintendent. It must always be borne in mind that a chain is only as strong as its weakest link, and the failure of one man in a staff means reduced dividends.

When one looks into the failure of industries to pay dividends, it is only too evident that capital has been squandered by men placed in responsible positions, without having the proper qualifications.

It is regrettable that such conditions exist when there is so much talent available, practically starving.

Qualified engineers are better adapted to design plants, than men with the gift of speech, costly errors would be avoided by the trained men, and an industry would have a reasonable chance to pay dividends if a few of these suggestions were followed.

---

## SHIPBUILDING IN CANADA.

On Tuesday, the 3rd inst., the ss. Canadian Pioneer was launched at Messrs. Canadian Vickers yards at Montreal. This is the pioneer boat of the Canadian Government's mercantile marine fleet which, according to present plans will aggregate a total of 39 vessels. The Canadian Pioneer is of 8,100 tons deadweight, 400 feet in length, 52 feet in breadth, and 31 feet in depth, with 3,000 indicated horse-power. In speaking at the launching, the Hon. C. C. Ballantyne said:

Mr. Lynch, Lady Borden, ladies and gentlemen:—

"My first duty is to thank Lady Borden for so graciously consenting to launch the 'Canadian Pioneer,' the first vessel of the Canadian Government's Mercantile Marine Fleet now under construction.

"I offer you, Mr. Lynch, and Canadian Vickers, Limited, my heartiest personal congratulations, as well as those of the Government for the energy and skill which you have displayed in making it possible to launch this morning the first of the Government's Mercantile Marine ships, the 'Canadian Pioneer' of 8,100 tons D.W., twin deck, 11½ knots sea speed and your further advice that the Canadian Voyageur of 4,350 tons, in a few days will be ready to proceed to sea under her own steam.

"This is a very commendable performance on the part of your company when it is considered that the keel of the 'Canadian Pioneer' which has just been so successfully launched was laid only on July 18 last, and the keel of the 'Canadian Voyageur,' which will be ready in a few days to proceed under her own steam to sea, was laid in March.

"It is a great personal pleasure for me to witness the launching of these two splendid ships this morning, for I am reminded that when I was one of the Harbor Commissioners for the Port of Montreal from 1907 to 1912 with my late colleagues, G. W. Stephens and L. E. Geoffrion, after long negotiation with the Vickers Company of London, England, we concluded satisfactory arrangements with them, whereby they decided to establish a branch of their business in the Port of Montreal, and not only erect the splendid modern shipbuilding plant that we are now in, but also the large floating dock that has a lifting capacity of 25,000 tons.

"It will be interesting, I am sure, Ladies and Gentlemen, to learn that the thirty acres of land that Vickers Works are situated on was reclaimed by dredging from the bed of the river.

### Government's Program.

"Therefore it is a special pleasure for me this morning to witness the development of steel shipbuilding in Canada, not only in the Vickers works, but in the other sixteen yards that are building steel ships for the Government, from Prince Rupert to Halifax.

"I am pleased to announce that the Government have under construction at the present time 39 steel vessels:

| | |
|---|---|
| Lake type | 9 |
| 4,300-ton type | 6 |
| 5,100-ton type | 8 |
| 8,100-ton type | 14 |
| 10,500-ton type | 2 |

"I have always been a great believer in Canada's possessing the necessary enterprise, skill and ability to build steel ships, and I am naturally very pleased and proud today that our country is making such progress in this new enterprise; and I hope that as the builders of steel ships in Canada gain more experience and knowledge they will be able to compete more effectually with other countries that have been so long in the shipbuilding industry.

"Canada requires tonnage, and very badly. It is estimated that owing to losses by enemy submarines the world's tonnage is at least ten million tons short of what it was when war broke out. We must also take into consideration that nearly every ship which is in service today requires repairs and docking owing to the fact that while the war was on these vessels could not be spared to go into dry-dock; and these conditions make the world's tonnage of shipping very much short of what it should be.

"Canada requires ships as speedily as they can be built, in order that they can be placed on the Atlantic and Pacific Oceans, as well as on the Great Lakes, to complete the Government's transportation system, and work in conjunction and co-operation with our Transcontinental system.

### All Government Owned.

"I have already announced that the Government's ships will be managed and operated by Mr. D. B. Hanna and his board of directors by the creation of a steamship company, the stock of which will be all owned by the Government, and the people may know what profit or losses the Government ships are making. Mr. Hanna and his board of directors have been given a free hand by the Government to manage the Government's system of railways, and they will be given an absolute free hand also in the management of the Canadian Government's mercantile marine.

"Happily war is now practically at an end, and Canada and its Government are confronted with the tremendous Peace problems. To retain our present volume of trade and to take the place of the vast sums of moneys that have been spent during the last few years in Canada for the making of munitions, it is imperative that Canada should vigorously go after export trade. The Government have laid the way for this by providing ships. The responsibility now rests upon the manufacturers of Canada to rise to the occasion and use every energy to secure export business. The United Kingdom, Overseas Dominions and our Allies are more sympathetically inclined than ever to buy Canadian products, and I hope that the manufacturers and business men of this country realize that this is the most favourable opportunity they have ever had to go after

export business. The Government is fully seized with this possibility and at the present time have a Trade Commission in London to see that the way is made easy for Canada to get her full share of the vast amount of materials that are going to be required for the restoration of devastated France and Belgium, and also to get her share of the vast amount of products of all kinds that will be wanted by these countries which have been engaged in war for the last four years, to replenish their stocks.

### Part Played by Marine.

"Before closing may I make reference to the splendid part that the Mercantile Marine has taken in this war. There has been altogether too little reference to it.

"The British Mercantile Marine have played a most important and noble part in bringing about the splendid victory that Great Britain and her Allies have secured I wish to take this opportunity, as Federal Minister of Marine, to pay my tribute to the brave men of England's huge Mercantile Marine, who manned her ships during these four terrible years of war, and so successfully have carried across the oceans millions of soldiers, immense quantities of munitions and provisions and have made it possible for us to so utterly defeat the enemy, with the aid of our Allies.

"Therefore I consider that this day is an epoch in the history of Canada and for the first time a Mercantile Marine flag of Canada has fluttered to the breeze on the 'Canadian Pioneer' just launched. With the lead that the Government has given and its determination to assist Canada in every way to do a large export trade, I hope in the very near future that the flag of Canada's Merchant Marine may be seen in every important port throughout the world, carrying to these distant countries Canada's production of the mine, field, forest and our industries, and bringing back the importations that Canada will find it necessary to make. All this is possible by co-operation of all of Canada's diversified interests.

"I wish every success to the 'Canadian Pioneer,' the 'Canadian Voyageur' and the other Government Mercantile Marine ships that are to be launched in the very near future."

## CONCRETE OIL TANKS.

(Hamilton Spectator.)

Canadian patent No. 177493 was today granted to J. B. Nicholson, the local civil engineer and contractor, covering a new design and improvements in the use of reinforced concrete for the storage of fuel and lubricating oils. Owing to the present scarcity of steel plate for tankage, this design was evolved as a conservation measure, and during the last eighteen months has been successfully constructed throughout the provinces of Ontario and Quebec to the extent of 1,000,500 gallons of storage. The question of efficiency of concrete in the presence of oils has been amply proven by this new method. J. B. Nicholson, Limited, the contracting firm handling the new construction, advise that many industrial firms, after thorough investigation, are specifying concrete for all future and additional oil storage. One of the above firm's important contracts for this class of storage is now nearing completion at Leaside, Ont., being a battery of ten 30,000 gallon tanks for the American government.

## MR. ROBERT HOBSON.

(Hamilton Spectator.)

As yet there has been little disturbance in labor and industrial circles, as a result of the signing of the armistice, although there has been a great easing off in munition work, which will cease altogether, no doubt, before Christmas. Munition workers who have been getting war rates of wages are now taking jobs at commercial rates.

The cessation of hostilities has had little effect at the plant of the Steel Company of Canada, the largest employer of unskilled labor in the city. Robert Hobson, president of the company, in an interview, estimated that his concern would increase its staff by ten per cent.

The problem of finding employment for labor will not be a critical one in the coming months, in the opinion of Mr. Hobson, and the development of an extensive export business in connection with reconstruction will speed the wheels of industry for some time to come. The need for steel rails and other equipment for all the railways of the country has resulted in the placing of large orders already, which will be speedily followed by others. Accessories are being ordered in volume, and work on these will need attention almost immediately.

In referring to the position of the Steel Company of Canada, Mr. Hobson stated that attention had been diverted from the munition industry during the last year, and that it had occupied a relatively small place in the industry in the last few months. Preparations for peace work were well advanced, and the active employment of labor was assured.

"I would point out that the successful return to a peace basis is contingent upon the production and consumption of our natural and manufactured products, which in turn governs the employment of labor, and will have a direct effect on the ability to absorb munition workers and returned soldiers into commercial pursuits. Co-operation between the government and manufacturers is necessary for a successful return to a peace basis. There will be presented Canada's claim for a share of the supplying of materials required in the restoration and rebuilding of devastated allied countries commensurate with the part Canada has played in the war. Already France has made enquiry for lumber equal to the total cut of British Columbia for three years.

"The Government has pledged itself to assist in financing such business by extending credit to the purchasing country, where necessary. The government is arranging an active program for the purchasing of rails, track fastenings, cars, locomotives and making general betterments which have had to be side-tracked during the war."

## MONTREAL METALLURGICAL ASSOCIATION JANUARY MEETING.

In view of the great importance of proceeding along the best possible lines in settling the Industrial Problems that are confronting us in Canada at the present time, it has been arranged that Mr. Warwick Chipman, K.C., will address the Association on this subject. Mr. Chipman is the Chairman of the "National Reconstruction Groups" which is trying to build up an enlgihtened puble opinion in this country by study and discussion in small groups. The meeting will be held in the Chemistry Building of McGill University at 8.15 p.m. on Tuesday, the 14th of January. All interested are cordially invited to attend the meeting and to join in the discussion.

# Hardness of Soft Iron and Copper Compared

By F. C. Kelley.

Research Physicist, General Electric Co., Schenectady, N.Y.

American Electrochemical Society, October, 1918.

*Abstract.*

Samples of American "Ingot Iron" and ordinary commercial cold-rolled copper were given similar treatments in an electrically-heated vacuum furnace, and then carefully tested for hardness by the Brinell methods. The treatment consisted in annealing several hours at 770 deg. C. to 950 deg. C., annealing in hydrogen and in a vacuum. Commercial copper ranged from hardness 80, as received, down to 40; ingot iron from 95 down to 60. The dead-soft iron can be whittled with a knife, and may find uses in place of pure soft copper. —(J. W. R.)

The experiments which I am about to describe were undertaken to determine how soft the purest grade of commercial iron produced in this country could be made after annealing, and how its hardness compared with that of copper.

The material used for these experiments was American ingot iron from two different manufacturers. The sheet bar material was 5-32 inch (4 mm.) thick. The copper was ordinarily cold-rolled copper from our stock room. Two different thicknesses, 3/4 in. and 5/8 in. (19 and 16 mm., were used in these experiments.

The hardness tests were all made by the standard Brinell method. The load applied in all tests was 500 kilograms, and the diameter of the ball used was 10 millimeters. Two different impressions were made upon each sample, so that we could have a check upon all tests.

The hydrogen annealing described below, under methods 3 and 4, which produced the best results, was done in a resistance furnace consisting of a porcelain tube wound with platinum ribbon. The wound tube was enclosed by a steel casing containing aluminum oxide for insulation. The hydrogen was dried and highly purified.

The vacuum anneal which gave the next best results was done in the Arsem vacuum furnace, which consists of a water- and air-tight casing containing a graphite grid or helix, gripped in water-cooled copper terminals, and enclosed by a graphite screen. The results of this anneal are given below under method 5.

Our factory anneal, given under method 2, below, is a treatment at 765 deg. C. for 12 hours in a furnace heated by oil. The sixth method of treatment described below consisted of inclosing the iron samples in a copper tube, closed at each end by a copper plug, and then inserting the copper tube into the porcelain tube furnace wound with platinum described above. This porcelain tube was also stoppered at each end.

The iron was subjected to eight different treatments, which are outlined below:

1. A sample of the iron as it came to us in the sheet bar un-annealed was first tested.

2. A commercial factory anneal was given to another where the temperature is held at 765 deg to 775 deg. C. for about 8 hours.

3. The factory-annealed sample, after being tested, was re-annealed in hydrogen at 900 deg. to 950 deg. C. for three hours.

4. Another set of samples was annealed in hydrogen at 900 deg. to 950 deg. C. for three hours, without a previous factory anneal.

5. The iron subjected to vacuum treatment was annealed at 1,000 deg. C. for about two hours.

6. Samples were enclosed in a copper tube stoppered at each end with a copper plug so as to make it nearly air-tight. This tube was placed in a closed electric tube furnace and annealed at 950 deg. C. for three and one-half hours.

7. A hydrogen annealed sample from the fourth experiment was rolled from 0.312 in. to 0.208 in. (8 to 5 mm.) or reduced to two-thirds of its original thickness.

8. A piece of the original sheet bar as received was given the same treatment as samples in experiment number seven.

The following are the Brinell hardness tests together with the treatments. Two tests are given on each sample:

| | Brinell Hardness. No. 1. | No. 2. |
|---|---|---|
| 1. Unannealed as it comes in sheet bars | 97.6 | 95.2 |
| 2. Factory annealed | 79.4 | 80.0 |
| 3. Factory annealed sample reannealed in hydrogen | 57.8 | 63.0 |
| 4. Hydrogen annealed | 62.2 | 61.0 |
| 5. Vacuum annealed | 62.2 | 65.8 |
| 6. Annealed in closed copper tube | 66.6 | 66.0 |
| 7. Cold rolled to 2-3 of its original thickness after a hydrogen anneal | 95.7 | 95.7 |
| 8. Cold rolled as received to 2-3 of its original thickness | 110.5 | 112.5 |

It is of interest to know that this hydrogen- or vacuum-treated iron may be whittled with a jack-knife as easily as our commercial copper.

The following are the analyses of the two makes of American ingot iron used in these tests, the iron having been determined by difference:

| | 1 | 2 |
|---|---|---|
| Iron by difference | 99.915 | 99.908 |
| Carbon | 0.05 | 0.06 |
| Manganese | 0.02 | 0.02 |
| Silicon | trace | none |
| Sulphur, gravimetric | 0.010 | 0.010 |
| Phosphorus | 0.005 | 0.002 |

Four different experiments were tried on the copper, which are given below:

1. Commercial copper bar as it comes to us was tested without any treatment.

2. Commercial copper bar 5/8 inch (16 mm.) in thickness was hammered cold to two-thirds of its orginal thickness.

3. A piece of copper bar 3/4 inch (19 mm.) in thickness was annealed in a commercial gas furnace to about 600 deg. C., so that it was dead soft.

4. A piece of the same bar after receiving commercial anneal was rolled to two-thirds of its original thickness.

The following are the results of the above tests:

| | Brinell Hardness. No. 1. | No. 2. |
|---|---|---|
| 1. Unannealed copper bar .......... | 82.2 | 79.2 |
| 2. Unannealed copper hammered to 2-3 of its original thickness...... | 87.4 | 96.8 |
| 3. Commercial annealed copper . .... | 40.6 | 40.2 |
| 4. Commercial annealed copper rolled to 2-3 of its thickness .......... | 89.4 | 92.6 |

The sample which was hammered was hit with a steam hammer, and shows that it received a little more working in one spot than another, due to the fact that the face of the hammer was not parallel with the block upon which the copper was hammered. To check the result, I rolled a piece of copper so that the reduction would be uniform, and the results are nearly the same.

The following conclusions may be drawn from these experiments:

American ingot iron subjected to a hydrogen anneal gives iron with a hardness about 20 points higher than that of dead-soft copper, while a vacuum anneal is nearly as good.

If annealed copper and annealed iron are each worked to produce a one-third reduction in thickness, the hardness of the copper increases over 100 per cent of its original hardness, while iron increases only about 60 per cent.

The range of hardness between dead-soft copper and commercial copper as we receive it is between 40 and 80, while the range of hardness between hydrogen-annealed ingot iron and the commercial material ranges between 60 and 95.

Carefully annealed ingot iron could be used in many places where copper is now used, because of its softness.

Research Laboratory, Gen. Elec. Co., Schenectady, N.Y.

## SILICO-MANGANESE.

The making of steel is very similar to the making of a pie, says Mr. J. W. Beckman, a member of the American Chemical Society. In a pie a number of various ingredients are mixed together, and produce the desired results, and such is also the case in making steel.

Among the most important ingredients which enter into steel manufacture, aside from the iron itself, are the metals manganese and silicon. These two metals added to the iron in various proportions give the necessary quality to the steel. Without them modern steel manufacture would be a failure.

Prior to the war, metallic manganese used in steel making was obtained from ores imported from Russia and smelted in the United States into an alloy known as ferro-manganese. Prior to the war, as is now the case, silicon was smelted in the United States in electric furnaces from quartz rock into an alloy known as ferro-silicon. These were the two sources from which the silicon and manganese necessary in steel were obtained.

The war has made enormous changes in the field of steel making. Germany has been deprived completely from obtaining manganese from outside sources. The United States has also been deprived, due to many circumstances, from obtaining the requisite amount of manganese ores from outside sources.

Germany has hunted through its mineral deposits and has found ores containing manganese and silicon together, and has smelted these ores and produced silico-manganese, an alloy containing in itself two of the essential metals necessary in successful steel manufacture.

The United States has been scoured all over for the purpose of finding valuable manganese ores. Ores have been found, especially in the West, in very large amounts, similar to those ores which have been the salvation of the German steel industries during these strenuous times.

Ferro-manganese can be produced from these ores, but, in so doing, part of the valuable metal manganese is wasted. Silico-manganese is produced to-day from these ores on the Pacific Coast, with no waste of the metal manganese. The manufacture of this silico-manganese alloy opens up unlimited ore reserves in the United States, which have had no value. Silico-manganese can do the same for the American steel industries as it has already done for the German.

# Report on Hardness Testing Relation Between Ball Hardness and Scleroscope Hardness

By A. F. SHORE (New York, U.S.A.).

With an Introduction and a Commentary by SIR ROBERT HADFIELD, F.R.S.

English Iron and Steel Institute, Sept., 1918.

### Introduction.

It may be remembered that at the May meeting of the Iron and Steel Institute I communicated the substance of a telegram I had received from Mr. Shore dealing with the relation between ball hardness and scleroscope hardness. This telegram, which was transmitted in the hope that it might interest the members present, ran as follows: "Have found apparent true scientific relation of ball and scleroscope the way to measure by ball faithfully up to 800°. Exhaustive analysis by both methods, and their relation to a constant depth variable load ball system."

This telegram was the outcome of a number of investigations made during the last few years on the subject of hardness determination, and of correspondence between Mr. Shore and myself. I was at that time

investigating hardness tests, particularly in the higher ranges, in the Hadfield Research Laboratory in Sheffield, with the object of finding a satisfactory factor for converting Brinell hardness numbers to scleroscope numbers, and vice versa. In the course of the correspondence referred to, the following questions were formulated and sent to Mr. Shore from the Hadfield Research Laboratory:

1.—Is it possible to find the relation between ball hardness, commencing with 150 up to 800, and scleroscope degrees? Also for each advance of, say, 50 Brinell hardness numbers, what is the difference in scleroscope numbers, and what is the necessary factor to convert each of these from Brinell into scleroscope numbers, and vice versa.

2.—Can a special scleroscope be supplied for determining in Brinell numbers instead of scleroscope, or both, highly hardened products ranging from 550 to 750 Brinell ball? The figures now obtained from the present apparatus do not appear altogether reliable. The scleroscope appears not to read to such a fine point as the Brinell.

Mr. Shore's replies having now been received, form the subject of the report which follows.

### Report on Hardness Testing.

With the object of throwing a light on the subject of the questions received from Sir Robert Hadfield, the author has undertaken an elaborate series of experiments, the results of which are shown graphically in the accompanying charts I., II., and III. A wide variety of metals, with different states of heat-treatment, and both ferrous and non-ferrous, were selected. The charts bear on the following aspects of this subject:

**Chart I.**—Relation between scleroscope and ball tests from the hardest to the soft metals, using 3000 kilogrammes throughout under 10-millimetre steel ball.

**Chart II.**—Relation of ball test and scleroscope, using 62 kilogrammes, 250 kilogrammes, 500 kilogrammes, and 750 kilogrammes, respectively. Above 325 Brinell or 60 scleroscope, a diamond sphere 10-millimetres in diameter was used, because of the flattening of steel ball.

**Chart III.**—The scleroscope against the number of pounds required to cause a 10-millimetre ball impression of 1 millimetre in diameter from the softest to the hardest metals. In this instance the depth and diameter of impressions were constant, while the pressure was the variable factor.

### Explanation of Chart I.

Curve A. It was not found possible to obtain a satisfactory conversion curve, as its wavy appearance indicates. More than this, the readings were widely scattered. This is probably due to the use of excessive pressures. From approximately 700 Brinell to 550, wide discrepancies are caused by flattening of the ball. From 550 down to about 200 Brinnell, abnormally high readings are obtained, due to the superhardening of this series of metals, which is necessarily possessed of marked toughness. Below 250 similar superhardening occurs, but Brinell readings have a tendency to fall below the best average line because the superhardening is neutralised by flow in the metal. In order that these tendencies may be shown out more clearly, a comparison is given in the dotted line B, B′, D, D′, taken from Chart II.

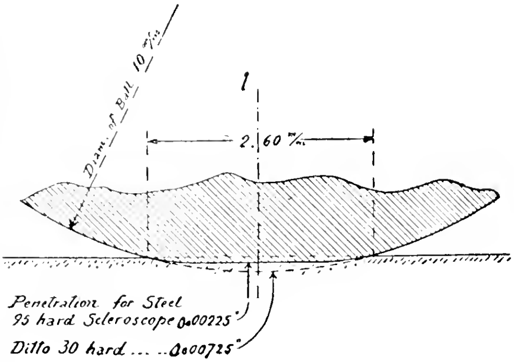



Fig. 1.

There is also included a chart drawn up by Mr. J. J. Thomas (Fig. 3), who has endeavoured to establish a relation between the Brinell (using 300 kg.) and scleroscope methods. Curve lines A and B were drawn by him. Curve C, which is irregular, is thought to be a better average, and has been drawn and added by the author. This curve corresponds quite well with curve A, Chart I., and shows the distortions caused by the several conditions named, which are due to use of excessive pressure.

### Explanation of Chart II.

Curve B, B′, C, C′, was produced by the pressures indexed in the chart, by the use of a steel ball. It was very difficult to read the impressions on steels above 80 hard scleroscope. It was soon observed that, using a steel ball above 450 Brinell or 85 scleroscope, a pressure of 750 kg. was insufficient. Hence the diamond sphere previously referred to was used. This pressure, and even 500 kg., was now sufficient and enabled the curve B, B′, to be continued up to nearly 800 Brinell,

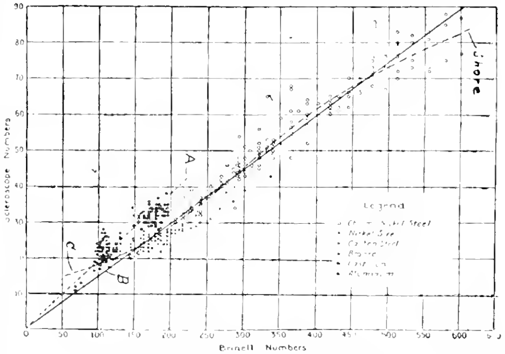



Fig. 3.—Comparison betwen Brinell-Ball and Shore-Scler scope Hardness Numbers.

with what the author regards as unusual consistency in its agreement with the scleroscope at the ratio graphically shown.

### Explanation of Chart III.

In the abscissa of this chart, the scleroscope numbers are used, while in the ordinates, the number of pounds required to produce an impression 1 mm. in

diameter, using a 10 mm. ball, are used. Curve E and E', therefore, represents a co-ordination of these values. The constant diameter and variable pressure system has been adopted, because this is theoretically the correct way of measuring absolute hardness under the resistance to penetration principle, and is therefore used as a means of investigating the scleroscope scale. It may just as well be used to investigate the Brinell scale.

In the past the author contented himself with checking up the Brinell method with the scleroscope and vice versa. The time has now come when both methods have been more or less questioned, particularly on the higher ranges of hardness, and hence the importance of curve E, E', which appears to supply the data necessary.

### Use of a Steel Ball versus a Diamond Ball.

Quenched carbon steel, 100 hard scleroscope, has a plane surface resistance to indentation of approximately 700,000 lbs. per square inch, whereas Brinell pressure at the same hardness, using 3300 kg., develops practically one million pounds per square inch. A steel ball can only sustain this load by flattening out. The result will then be that the penetration will be one-third as much as it will be in annealed carbon steel for the same diameter of impression as per diagram Fig. 1.

Above 85 hard scleroscope there appears to be a kind of adjustment between the steel ball and the sample under test, which has a tendency to cause an indentation having always the same diameter, regardless of a considerable variation of hardness of the said sample as indicated by the scleroscope, or as can be indicated by the Brinell method, using a diamond sphere.

Thinking that the flat on the steel ball which had been caused by previous tests may have been the cause of the lack of discrimination, a series of tests were made on the same block of steel, using each time a new and round surface, followed by a second test, without changing. In other words, testing with the previously flattened ball, a difference of from 100 to 150 Brinell numbers could be obtained in this way; the flattened ball reading always lower than the unflattened ball. These impressions are illustrated in Chart I. The hardness of the ball used was 105 scleroscope, although the average run, as usually supplied to the trade, is about 100 hard.

As far as the author's experiments have gone, he has been led to the conclusion that by the use of a steel ball no consistent results can be obtained above 85 hard scleroscope. By the use of a diamond, at a pressure of 750 kg., the value of the most intensely hard steel can be ascertained as per his curve B, B', D, D'. The diamond (yellow) has a resistance of approximately 1,250,000 lbs. to 2,000,000 lbs. to the square inch, provided, of course, it has been carefully selected and its cleavage planes are at right angles to the plane of the test sample. The highest pressure employed on carbon steel 105 hard in Chart II, was 1,125,693 lbs., thus showing that it is dangerously close to the limit. While it has thus been shown that the diamond can be used under the Brinell press measuring steel at its highest hardness, it hardly lends itself to commercial application for the following reasons: (1) The indentations made are so small as to be extremely difficult to read even under perfect laboratory conditions. (2) The loss due to breakage of diamonds would almost be prohibitive. In the experiments the regular hydraulic Brinell testing machine was not considered as accurate enough for the use of the diamond under 750 kg. An ordinary beam weighing scale arrangement was substituted. One or two seconds of time was allowed; more time did not materially influence the results.

### Relation of Scleroscope to Brinell.

Curve B, B', D, D' is regarded as one indicating with as much accuracy as can be reasonably expected the true relation between scleroscope and Brinell methods. It is readily seen that the relation is a sliding one, as indicated in the short heavy black cross marks on the upper part of the chart, in which each division represents 50 deg. Brinell. Assuming that the diamond could be made to stand up better than it does under 750 kg., the pressure curve B, B', D, D' would appear to substantiate Sir Robert Hadfield's claim that on the higher hardnesses the Brinell method discriminates more delicately.

When the several conditions which have to be reckoned with, however, are considered, such as: (1) The condition of the surface; (2) errors in measurement, which often approach 75 Brinell numbers on the same piece, carefully and uniformly hardened; (3) the time allowable in commercial practice; (4) the rapid fatigue of the operator, it will be seen that the scleroscope, which regularly uses a diamond, will, after all, discriminate the closest on hard steel.

An advantage of this instrument is that dozens of tests can be made and average upon the same sample, agreeing within 2 deg. or 3 deg. of each other.

### Constant Depth System.

While this provides a very good check for any penetration-measuring machine, and can be used on the hardest steels, it is necessary to use a diamond on hardnesses over 80 scleroscope. This demands that the indentations made shall be very small—not much more than 1 mm. in diameter—and these, as before pointed out, are too small to be read with accuracy in general commercial practice.

While, as before stated, the constant depth variable load system can be readily applied on the harder steels by the use of a diamond, it is particularly advantageous on the softer materials, not only metals, but all substances, even elastic rubber. Hitherto there had been no way of measuring the hardness of organic compounds or materials, because of the peculiar fibrous structure or resilient properties. By this method it is very easy to measure the amount of pressure required to cause a fixed penetration. This will provide a reading which is not influenced in the slightest degree by any peculiar physical property save that of resistance to penetration or hardness. It may therefore be said to lend itself to the testing of true hardness on any known substance which is not too brittle.

### The Scleroscope Provided with a Brinell Scale.

Reference to the accompanying charts will show that it is a very simple matter to provide the scleroscope with a corrected Brinell scale as per curve B, B' and D, D', or the constant depth variable pressure curve E, Chart III. As before stated, the relation for each set of de-

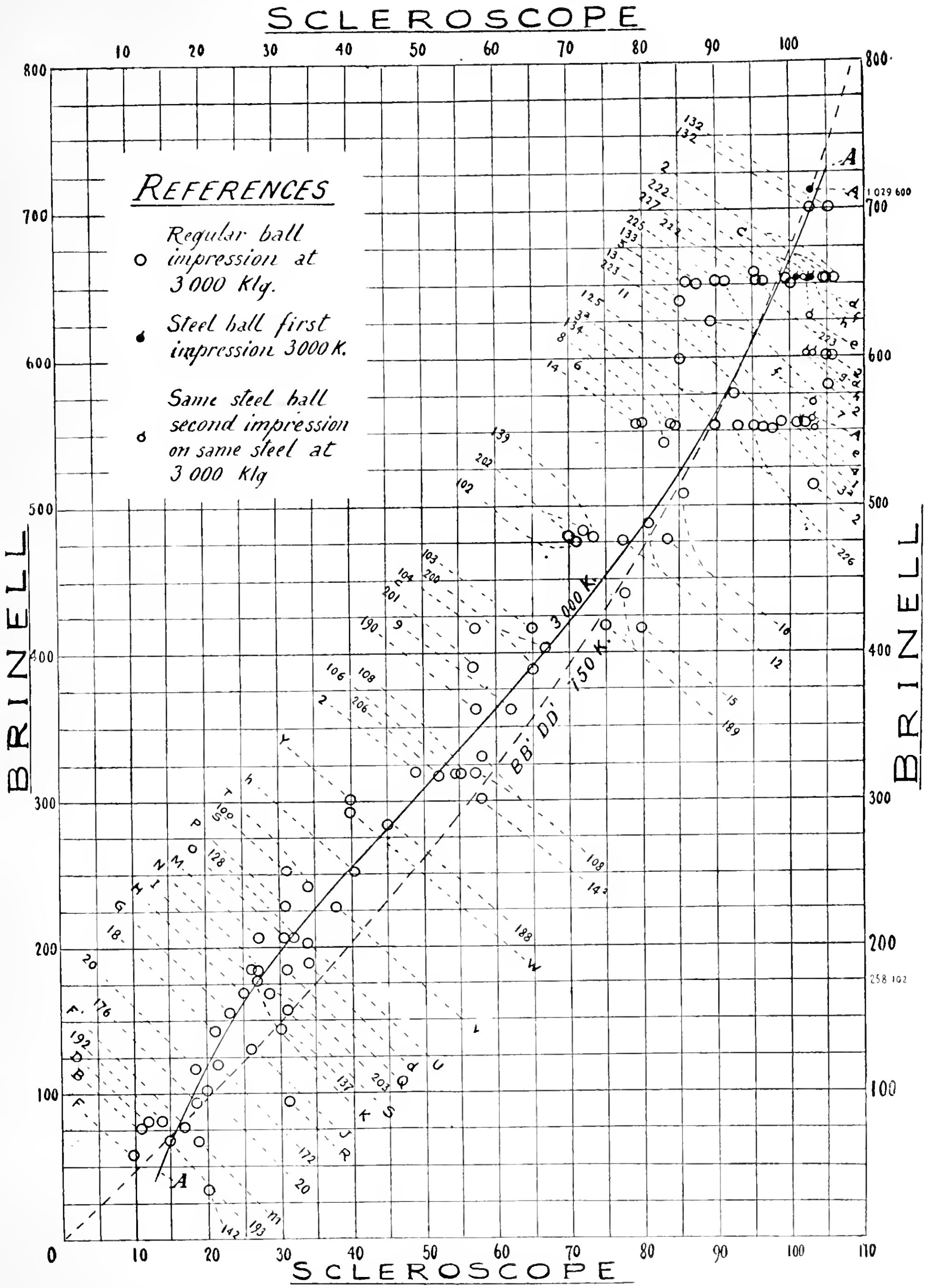

SCLEROSCOPE
REFERENCES
Regular ball impression at 3 000 Klg.
Steel ball first impression 3000 K.
Same steel ball second impression on same steel at 3 000 Klg
BRINELL
3 000 K.
150 K.
BB' DD'
SCLEROSCOPE

Chart I.

PLATE II.

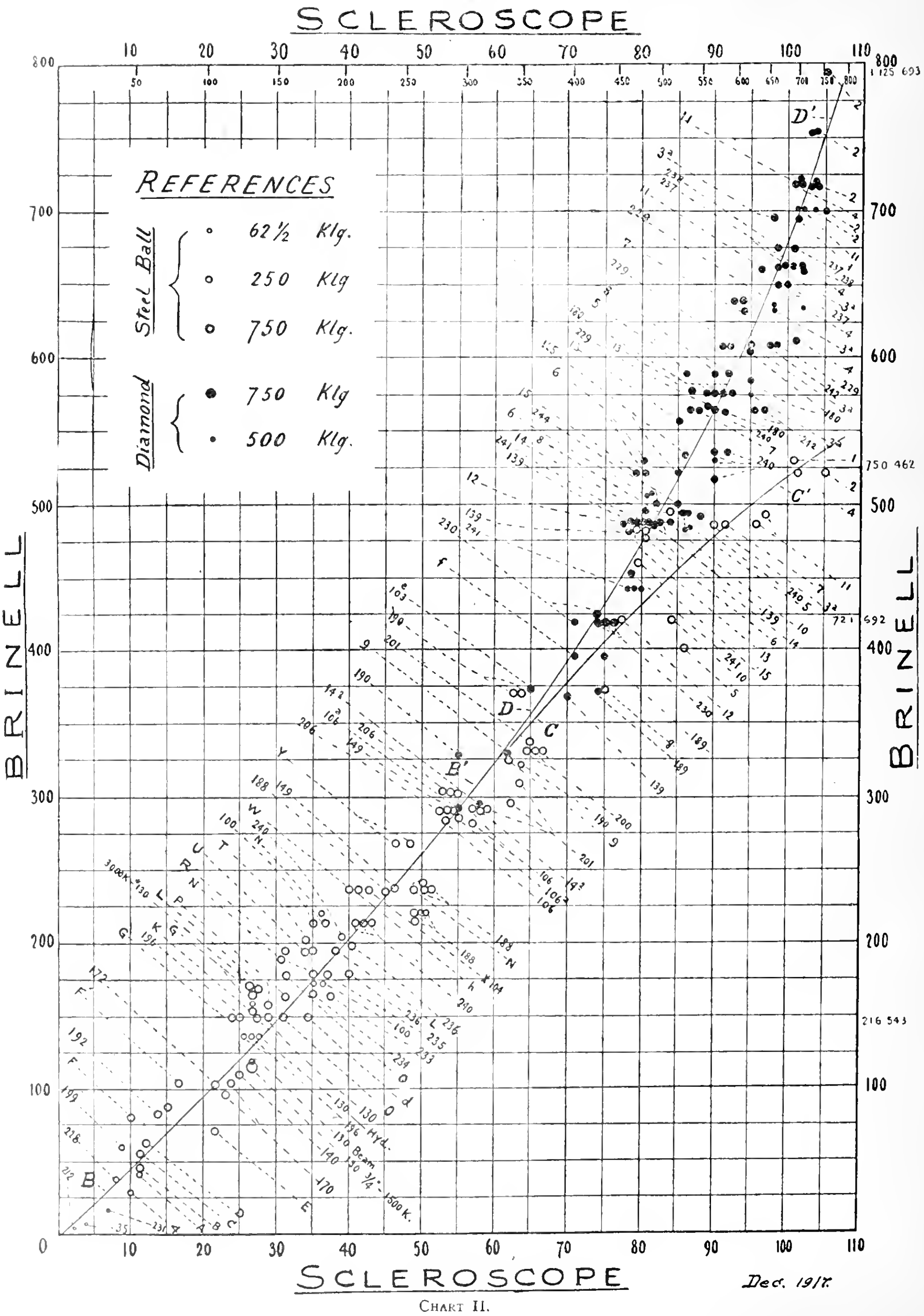



CHART II.

PLATE III

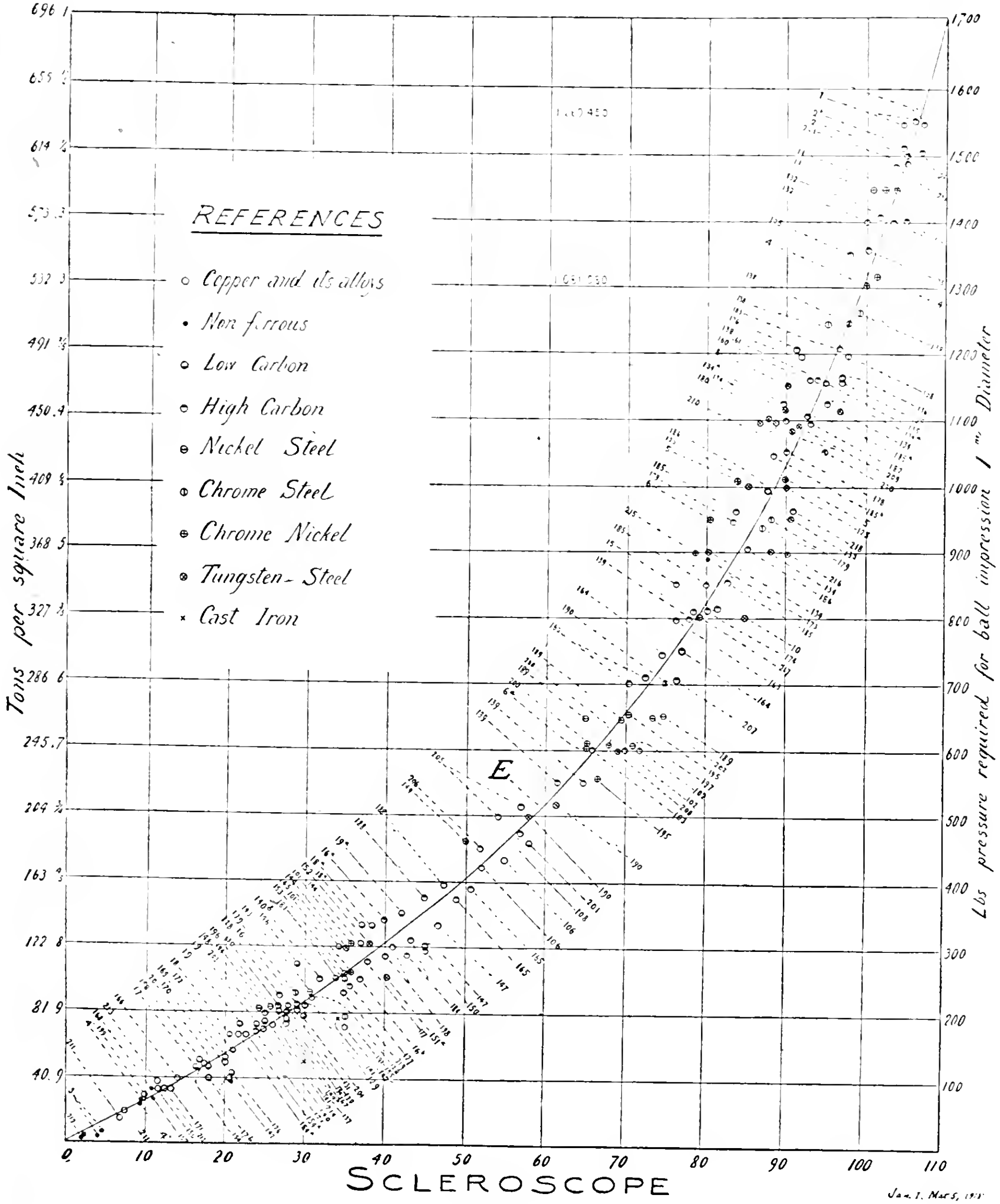



CHART III.

grees is of a sliding character, meaning that on the upper scale the size of the degrees would become less and less. In other words, they would be compressed.

Sir Robert Hadfield's suggestion that the scleroscope may perhaps be used for indicating the hardness with closer discrimination than it had been possible in the past on metals of high hardness was made the subject of an experiment. This consisted of reducing the standard area of the diamond point of the scleroscope, so that where formerly it showed 100 on quenched steel of this hardness, it now only showed 75. It was thought that by this arrangement smaller differences of hardness in these hardened steels would be magnified because of the greater striking force or rebound that would be possible by carrying the present 100 mark down further. While it is true that in this way hardnesses greater than is now found in steel can be measured, nothing was gained, and there was no closer discrimination, in fact not so close, for the reason that the hardness degrees were 25 per cent smaller on the whole scale.

### Relative Hardnesses.

The hardness of lead compared with that of steel 100 hard scleroscope in terms of pounds required to cause a standard ball impression of 260 to 1 is by the Brinell method 145 to 1. By the scleroscope standard scale, taking 100 hard as the average for quenched steels, the relation is 50 to 1. This shows that neither of these two instruments gives the true relative hardness. This, however, while important to know, is of little importance in general practice for the reason that each scale may now readily be converted into the other.

### Influence of Pressure on Ball.

The several tables of figures given by Sir Robert Hadfield as representing progress made, showing the relation of Brinell using a pressure of 3000 kg. and that of the standard scleroscope, vary considerably, as will be seen by comparison with one another. They also are not in perfect agreement with the results obtained by the author and hereby submitted, using both 3000 kg. and 750 kg. The study of Chart II. will disclose that a curve resembling that of E, Chart III (closest), is obtained by the use of a lower pressure. The curve is gradual, consistent, and, in the author's estimation, scientific. It will be noted here that on hardened steels both 500 and 750 kg. have been used. This did not materially influence the results obtained, and if anything the 5000 kg. readings are closer in agreement to the scleroscope than the 750 kg. ones.

On the soft metals there appears to be convincing evidence that the hardness readings are influenced by the amount of pressure put on the ball. At the Fifth Congress of the International Association for Testing Materials at Copenhagen, 1909, Dr. P. Ludwik, of Vienna, discussed this phase of the question. He recognised the varying amount of flow phenomena and of cold working due to pressure which changes the original hardness of the material so that a particular metal will show different readings dependent upon the amount of pressure upon the ball.

In a specimen of annealed carbon steel (28 hard scleroscope) that we have investigated, we have found the following: E.L. resistance to compression of a cylinder ½ inch in diameter, 75,000 lbs. per square inch; tension, 42,000 lbs. per square inch; the same steel under a flat punch on its plane surface offers a resistance of 102,000 lbs. per square inch—that is to say, this is the point at which it begins to take visible permanent set.

The following are the pressures exerted by the scleroscope and ball tests, the latter using a series of different pressures on the soft metal:

Scleroscope, 160,000 lbs. per sq. inch, hardness 28.
Ball Test (10 mm. diameter):
500 kg., 170,000 lbs. per sq. inch, hardness 120.
750 kg., 216,000 lbs. per sq. inch, hardness 150.
1000 kg., 231,630 lbs. per sq. inch, hardness 159.
3000 kg., 258,000 lbs. per sq. inch, hardness 170.
4500 kg., 277,000 lbs. per sq. inch, hardness 182.

*Carbon Steel Hardened.*

Scleroscope 943,000 lbs. per sq. inch, hardness 100.
Ball Test (10 mm. diameter, using diamond):
750 kg., 995,000 per sq. inch, hardness 680.

At the Sixth Congress, International Association for Testing Materials, held in New York, 1912, Prof. Albert Sauveur, of the Harvard University, presented an interesting paper on Stead's discovery of spontaneous growth of strained ferrite grains when exposed to temperatures close to but below the thermal critical range of the metal. In this he gave several illustrations of the effect of varying pressure on the Brinell ball as used for testing hardness. When the pressure just exceeds the elastic limit, the greatest possible crystal growth occurs. When it is great enough to cold work the metal, however, or considerably to compress it so as to increase its original hardness, little or no crystal growth is noted.

In the photographs in Plate IV.[1] No. 1 show the extent to which the elastic limit of the metal has been overcome under and around the ball indentation, which in this instance carried 3000 kg., while photograph No. 2 shows the diameter of the affected metal after cutting away the top just below the bottom of the indentation in same specimen, using the same pressure.

In photograph No. 3 only 1000 kg. have been used. The depth and diameter of the metal affected is of course less, but the coarseness of practically all the crystals indicates that the pressure used was little more than enough to overcome the elastic limit.

### Hardness and Elastic Limit.

It has been the author's claim from the outset that the scleroscope, which uses comparatively light pressures—just enough to overcome the elastic limit automatically regulating its impact pressure—measures a value closely associated with the elastic limit. For the Brinell test, on the other hand, it has been claimed that by the use of the ball method a symbol which leans toward, and in fact which measures, the ultimate strength is given.

Here it would appear obvious that two methods which tend in opposite directions cannot be expected to agree as well as if they both tended in the same direction, as toward the elastic limit. In view of this fact, it would appear obvious that if a scientific relation between the ball and scleroscope tests were established, the tendency toward the ultimate strength would have to be eliminated and the tendency toward the elastic limit would have to be adopted. This would mean that the ball test must not use much more pressure per square icnh than is exerted by the scleroscope.

The author regards 1000 kg. on a 10 mm. ball as certainly the limit. 750 kg. is perhaps much nearer to being scientifically correct, that is, if the ball test is to be made to agree in a definite manner with the scleroscope or the constant depth scale, Chart III. He regards 3000 kg. as absolutely excessive, as the above table of figures shows. If the ultimate strength is to be

---

[1] We have numbered these 1, 2 & 3.

investigated without attempting to find a satisfactory relation to the scleroscope scale, a pressure of 3000 kg. may be used.

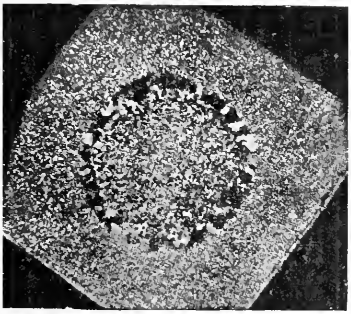
Whether this would be too low or excessive would appear to be determined by that which is necessary to cause the limit of hardening by cold working. Reference to Chart I. shows that there is a decided drop in the curve at 20 to 25 hard scleroscope, which would appear to indicate that 3000 kg. for investigating ultimate strength is excessive, in that flow occurs without further mechanical hardening.

**Test Samples Used.**

A complete list of the series of metals which were used for making comparative tests, and which are numbered on the charts, is given further on in this article. It may be added that in carrying on this interesting work the author was ably assisted by Mr. F. G. Kendall, of Pittsburg, and by his brother, Mr. Charles P. Shore, who selected and prepared the diamonds; also most of the test samples.

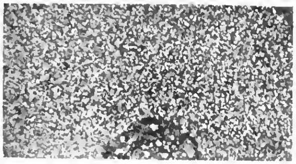
No. 1.

Steel, subjected to ball test under pressure of 3000 kgs. and annealed at 650 deg. C. for seven hours. Vertical section through bottom of depression. Magnified 6 diam.



No. 2.

Same steel tested and treated as indicated under Fig. 2. Horiontal section through bottom of depression. Magnified 6 diam.



No. 3.

Same steel, subjected to ball test under a pressure of 1000 kgs. and annealed at 650 deg. C. for seven hours. Vertical section through bottom of depression. Magnified 6 diameters.

Reduced by one quarter.

**Commentary by Sir Robert Hadfield:**

1. Briefly Mr. Shore's statements appear to indicate the following:

2. Chart I. shows the statements he puts forward with regard to correlating scleroscope and Brinell tests, the latter carried out under the ordinary conditions, that is, with 3000 kg. pressure. He shows that there is no very definite relation on these lines, which, of course, is in line with our and other people's experience.

3. Looking further into the matter, he sees that the trouble lies in the way the Brinell test is usually carried out, that is, using a standard pressure of 3000 kg., and obtaining a different size of impression for different materials. This is fundamentally wrong, and instead the Brinell method should be so used as to obtain the same size of impression on every material, no matter what the hardness (the pressure required to do this is then the measure of the hardness).

4. Of course this is still inside Brinell's definition, but another and better way of carrying out the test. The reason why this gives a better indication of the Brinell hardness is that each specimen is deformed to the same extent. Consequently the effect of deformation hardness is the same for all.

5. Mr. Shore argues also that his scleroscope test does not much exceed the elastic limit of the material, and, therefore, is a guide more particularly to the elastic limit, whereas the ordinary Brinell test much exceeds the elastic limit, and, therefore, is more of a guide to the tenacity, so that the scleroscope and ordinary Brinell tests cannot be expected to correlate very closely.

6. By reducing the pressure in the Brinell test so as not to exceed the elastic limit appreciably, better correlation should be expected between the two methods. His arguments are fully justified by Chart III., where he has got a very good relation between the two on a very wide range of materials.

7. As comment on the above, it has, of course, to be recognised that Brinell tests are commonly carried out with 3000 kg. pressure, and therefore Chart I., imperfect as it is, is really the best chart for comparing scleroscope and Brinell.

8. Chart III. shows how scleroscope and Brinell compare when the Brinell test is carried out on ideal lines. It is to be feared, therefore, that it is, at the moment, only of academic interest, though it makes out a strong case for revising the method of carrying out the Brinell test; but as Mr. Shore points out, the use of small pressures means impractical impressions. No doubt the difficulty of producing a definite size of impression on any specimen, whatever the hardness, could be got over by refinement of the apparatus. Certain-

ly by revising the Brinell methods on these lines we should get a hardness figure which represents something more definite as to the hardness than the present method gives. As Mr. Shore points out, a different hardness figure is obtained when using 1000 kg. pressure to that when using 3000 kg. pressure, due to the larger amount of deformation in the latter case.

9. Quite a separate point is the use of a diamond ball. This is certainly very interesting indeed, and from Mr. Shore's results gets over the difficulty of the deformation of steel balls when testing hard specimens (see Chart II.) Unfortunately, diamond will not stand more than about 750 kg. pressure, so that it is not a very practical material, but it has enabled him to prove the point definitely that fictitious hardness figures are obtained on hard specimens due to the deformation of the steel ball, which, of course, we have always suspected. Notwithstanding its limitations, the use of this diamond ball helps considerably in the direction of obtaining the true hardness of hardened steel, and in this respect it is the best device hitherto put forward in competition for the Hadfield prize.*

10. It may be added as regards the method of using the Brinell test with a standard indentation instead of a standard pressure, that this point has been well realised in the Hadfield Research Laboratory work; in fact it has the additional advantage that if the diameter of the impression is kept in a definite relation to the diameter of the ball, good comparison is obtained between tests made with different sizes of ball. The difficulty is in applying this principle to practical tests in the works, and having applied it, it would mean that a different hardness figure from the present one would in many cases be obtained. If the present figures are obtained in what is scientifically a wrong manner, they ought to be discarded in favour of more rational figures. If Mr. Shore can devise a practical Brinell testing apparatus which embodies this principle, that is, makes a defiinte size of impression on specimens of all grades of hardness, it would usefully supersede present methods. If these are wrong they are nevertheless well established all over the world, and cannot, therefore, be dislodged in a hurry.

## APPENDIX I.

## Hardness Tests: Relation Between Brinell Ball Test and Scleroscope Readings.

By J. J. Thomas (Watertown Arsenal, U.S.A.)

A number of inquiries have recently reached Watertown Arsenal as to the proper factor to convert Brinell ball-test hardness numbers to scleroscope readings. Many manufacturers and laboratories have one of these instruments, but few have both. In order, therefore, to compare the hardness of their product with that of another factory or to interpret the results given in various papers and journals, it is necessary that the factor connecting the two be known.

The curves shown in Fig. 2 (Plate V.) were plotted after taking over 500 readings. All Brinell impressions were made with an "Alpha" machine having a steel ball 10 mm. in diameter, with a pressure of 3000 kg. for 30 seconds. The scleroscope readings were taken with a Shore instrument, having a diamond-tipped hammer.

Different metals have been given different symbols in order that the relative hardness may be quickly noted. The full line gives the relation for steels, and is believed to be a representative curve. For this line the factor is 6.67, that is, the scleroscope reading multiplied by 6.67 gives the Brinell ball hardness numbers.

It was found on plotting the values for cast iron and bronzes that all points were above this line. The broken line shown was therefore plotted, giving a factor of 5.25 for these metals. The three points for aluminium lie between these two lines, giving a factor of about 6. The points for nickel steel lie below the full line, and for these the factor 7.7 seems more suitable.

From the above it is seen that the factor is not constant, but varies with the different metals. In fact, considerable variation is found even in the same metal. The scleroscope readings vary more than the ball tests, probably owing to the fact that the scleroscope measures the hardness of very small areas, and these areas vary in hardness even in the same metal.

It has been found that for hardness numbers above 300 Brinell or 45 scleroscope, metals are very difficult

TABLE I.—*Comparison of Brinell Ball and Scleroscope Hardness Numbers with Compression Strength, also Yield Point and Tenacity of Steel*

PREPARED BY SIR ROBERT HADFIELD.

This table represents the average of a large number of tests on all types of steel, and is intended as an approximate guide. Individual results very considerably from the average.

| Zones of Hardness F to A | Approximate Scleroscope Hardness Number. | Brinell Ball Hardness Number. | Tensile Strength. Yield Point. Tons per Sq. In. | Tensile Strength. Yield Point. Kg. per Sq. Mm. | Tensile Strength. Maximum Stress. Tons per Sq. In. | Tensile Strength. Maximum Stress. Kg. per Sq. Mm. | Compression on Specimens 0·564 inch diameter and 0·70 inch in height. Elastic Limit and 0·25 per Cent. Compression. Tons per Sq. In. | Elastic Limit and 0·25 per Cent. Compression. Kg. per Sq. Mm. | Compression per Cent. (100 tons per Sq. In.). (160 Kg. per Sq.Mm.). |
|---|---|---|---|---|---|---|---|---|---|
| F | ... | 150 | 20 | 31 | 36 | 57 | 17 | 27 | 49·0 |
| | ... | 175 | 26 | 41 | 41 | 65 | 19 | 30 | 40·0 |
| | 34 | 200 | 32 | 50 | 46 | 72 | 21 | 32 | 35·0 |
| E | 38 | 225 | 38 | 60 | 51 | 80 | 23 | 38 | 31·0 |
| | 42 | 250 | 44 | 69 | 56 | 88 | 26 | 41 | 27·0 |
| | 48 | 275 | 50 | 79 | 81 | 96 | 30 | 47 | 23·0 |
| | 50 | 300 | 56 | 88 | 66 | 104 | 34 | 54 | 19·0 |
| D | 54 | 325 | 81 | 96 | 71 | 112 | 38 | 60 | 15·2 |
| | 57 | 350 | 67 | 105 | 76 | 120 | 43 | 68 | 11·3 |
| | 61 | 375 | 73 | 115 | 81 | 128 | 49 | 77 | 8·0 |
| | 64 | 400 | 79 | 124 | 86 | 135 | 55 | 87 | 5·8 |
| C | 68 | 425 | 84 | 132 | 91 | 143 | 61 | 96 | 3·8 |
| | 71 | 450 | 90 | 142 | 96 | 151 | 67 | 105 | 2·4 |
| | 75 | 475 | 96 | 151 | 101 | 159 | 74 | 116 | 1·3 |
| | 78 | 500 | 102 | 181 | 106 | 167 | 81 | 127 | 0·6 |
| B | 80 | 525 | 107 | 169 | 111 | 175 | 87 | 137 | 0·23 |
| | 84 | 550 | 113 | 178 | 116 | 183 | 94 | 148 | 0·21 |
| | 86 | 575 | ... | ... | 121 | 190 | 101 | 159 | 0·20 |
| | 89 | 600 | ... | ... | 126 | 198 | 108 | 170 | 0·18 |
| A | 92 | 625[1] | Not determined. | | 131 | 206 | 115 | 181 | 0·16 |
| | 95 | 650 | | | 136 | 214 | 122 | 192 | 0·14 |
| | 99 | 675 | | | 141 | 222 | 129 | 203 | 0·13 |
| | 101 | 700 | | | ... | ... | 136 | 214 | 0·12 |
| A2* | ... | 725 | Not determined. | | Not determined. | | 144 | 227 | 0·11 |
| | ... | 750 | | | | | 151 | 238 | 0·09 |
| | ... | 785 | | | | | 159 | 250 | 0·08 |
| | ... | 800 | | | | | 166 | 261 | 0·07 |

[1] Glass scratching hardness commences here.
* Owing to want of data, but little is known about this extremely high zone of "superhardness"

*Sir Robert Hadfield recently placed in the hands of the Institution of Mechanical Engineers the sum of £200, which with any income therefrom may be awarded at the discretion of the Council of the Institution as a prize, or as prizes, for the description of a new and accurate method of determining the hardness of metals, especially of metals of a high degree of hardness. The award or awards will be made by the Council of the Institution of Mechanical Engineers, whose decision will be in all cases final. The Council will consider annually all communications received, and may then award a prize or prizes, but in January 1922 the offer of prizes will be withdrawn, and any unexpended balance of the Prize Fund will be diverted to any other purposes to be determined at the discretion of the Council.

PLATE V

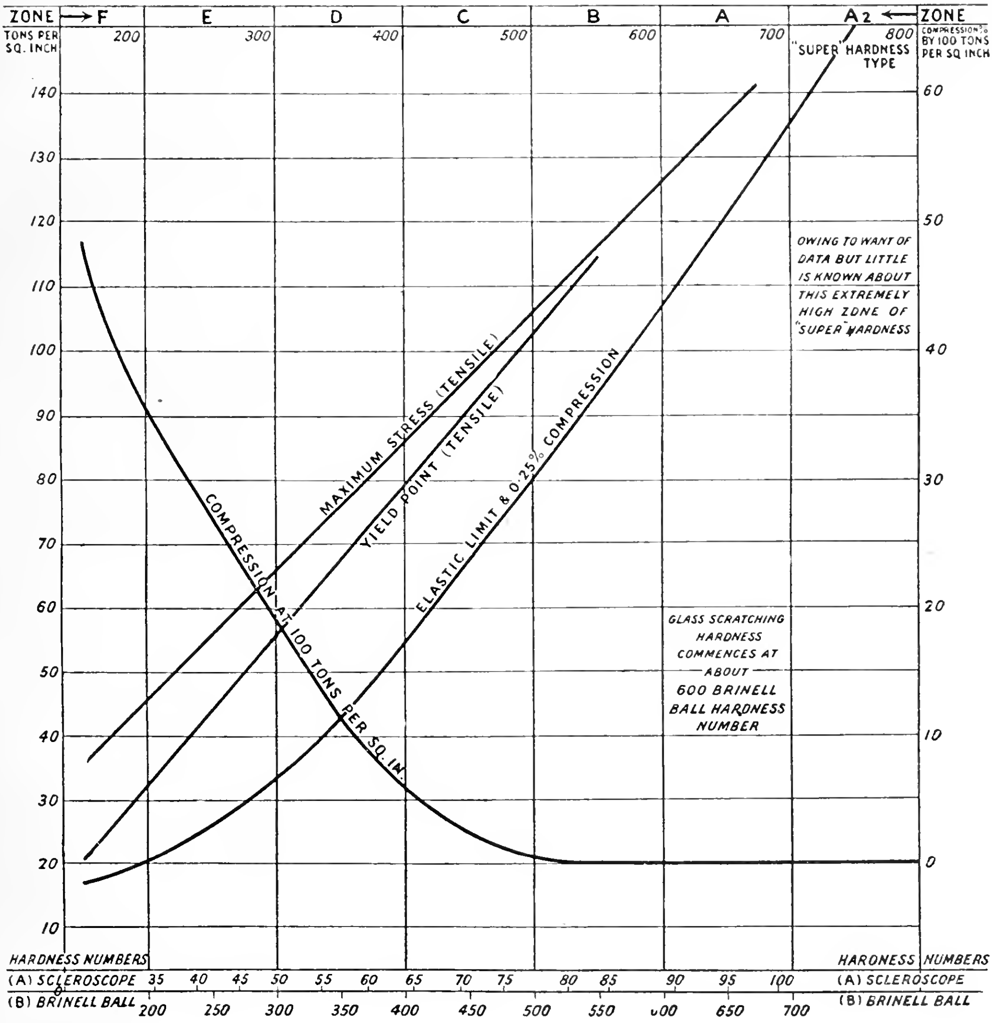



FIG. 2.

Diagram showing comparison of Brinell Ball and Scleroscope Hardness Numbers with Compression Strength, also Yield Point and Tenacity of Steel, varying from the softest to the hardest "super" hardness types.

(This Diagram has been prepared by Sir Robert Hadfield from the data of Table I.)

to machine. Tempered steels lie in the range of 150 to 300 Brinell.

No attempt has been made to compare the accuracy or usefulness of the two instruments, as it is believed that each has a place in the testing of materials.

The capital letters in the zone column refer to special sections of zones of hardness as follows:

| Zone. | Brinell Ball Hardness Number. | | Scleroscope Hardness Number. | | Yield Point. Tons per Sq. Inch. | | Maximum Stress. Tons per Sq. Inch. | |
|---|---|---|---|---|---|---|---|---|
| | From | To | From | To | From | To | From | To |
| F | 150 | 200 | 34 | 34 | 20 | 32 | 36 | 46 |
| E | 200 | 300 | 50 | 50 | 32 | 56 | 46 | 66 |
| D | 300 | 400 | 64 | 64 | 56 | 79 | 66 | 86 |
| C | 400 | 600 | 78 | 78 | 79 | 102 | 86 | 106 |
| B | 500 | 600 | 89 | 89 | 102 | Not determined. | 106 | 126 |
| A | 600 | 700 | ... | 101 | Not determined. | Not determined. | 126 | Not determined. |

## APPENDIX II.

## List of Metals and Materials Used in the Experiments

(See Charts I., II., and III.)

A. Aluminium.
B. Brass, cast.
C. Copper, annealed.
D. Brass, annealed.
E. Zinc.
F. Copper.
G. Machine steel, soft, 5-16 x 1 1/4.
H. Machine steel, annealed.
I. Nickel steel.
J. Brass, hard.
K. Chrome tool steel.
L. Nickel steel.
M. Machine steel, CR.
N. Manganese steel, ductile.
O. 1 per cent carbon steel, unannealed.
P. Manganese steel, brittle.
Q. Manganese bronze.
R. Phosphor bronze.
S. High-speed steel, annealed.
T. High-speed steel, annealed, No. 100.
U. Vanadium steel.
V. Projectile steel, annealed.
W. 2 per cent carbon steel.
X. High-speed steel, compressed, 5-16 x 1 1/4.
Y. 1.65 per cent carbon steel, 1/2 x 1.
Z. 1.65 per cent carbon steel, 1/2 x 1.
a. Tool steel, No. 106.
b. Tool steel drawn, 1 x 3 inch bat.
c. High-speed steel, drawn at 1400 deg. F., No. 104.
d. Cast iron.
e. Tool steel, No. 103.
f. Tool steel, No. 102.
g. 6 per cent nickel steel.
m. Bessemer steel rod.
1. 1 3/4 inch square 1.10 carbon steel.
2. Ditto, full hard.
2a. Ditto, full hard.
2b. Ditto, on end.
3. Tin.
3a. High-speed steel gear.
4. Bethlehem projectile steel, full hard.
4. Aluminium plate, annealed.
5. Bethlehem projectile steel, drawn at 480 deg. F.
6. Chrome nickel steel.
6a. Bethlehem projectile steel, drawn at 800 deg. F.
7. High-speed steel block.
8. 5/8 x 3/8 inch high-speed steel bar.
9. 1/4 x 1/2 inch high-speed steel.
10. 3/8 x 1/2 inch high-speed steel.
11. Bethlehem projectile steel, full hard.
12. Chrome nickel steel gear.
13. Chrome nickel steel bevelled gear.
14. Chrome nickel steel bevelled gear.
14-2 Chrome nickel steel, softer hub.
15. 1 x 1 inch 1.25 carbon steel, tempered.
16. Drill rod, annealed.
16a. Drill rod, cold-rolled.
16b. Drill rod, unannealed.
17. Mild steel, 3/8 x 5/8 inch.
17a. Ditto, cold-rolled.
17b. Ditto, annealed.
18. Ditto, 3/4 inch square.
18a. Ditto, cold-rolled.
19. Ditto, 3-16 x 1 inch.
19a. Ditto, cold-rolled.
20. Ditto, 1 x 1/2 inch.
20a. Ditto, cold-rolled.
100. High-speed steel.
101. Projectile steel, annealed.
102. 1.25 carbon steel, 1 inch square.
103. Ditto, drawn.
106. Ditto.
108. Ditto, drawn.
125. High-speed steel, 1/8 x 1 inch.
126. Chemically pure iron.
127. 12.5 carbon steel, 1 inch square.
128. Ditto.
129. Ditto.
130. Ditto.
131. 1.52 carbon steel, 1 inch square.
132. Ditto.
133. High-speed steel, 1/8 x 1 inch.
134. Ditto.
134a. 1.25 carbon steel, 1 x 1 inch.
135. Ditto.
136. Ditto.
137. Cast iron.
138. 4-inch ball-bearing.
139. 1.25 carbon steel, drawn, 500 deg. F.
140. 1/8-inch plate, brass.
140a. Manganese steel, ductile.
140.b. Ditto, brittle.
141. Cast iron, 3/8 x 1/4 inch.
142'. Manganese bronze bar.
142. Zinc, 1-inch bar.
143. Commercial nickel steel.
144. Machine steel, cold-rolled.
145. Ditto.
146. Ditto, annealed.
146. Ditto.
147. 1 per cent carbon steel, unannealed.
148. Nickel steel, annealed.
149. Chrome nickel steel, annealed.
150. 2 per cent carbon steel.
151. Steel casting.
152. Annealed high-speed steel, compressed.
152a. Ditto.
153. Vanadium steel.
154. Phosphor-bronze bar.
154a. Ditto.
155. Ditto, casting.
156. Brass, cast.

157. Aluminium, hard.
158. Copper, hard.
159. Copper, soft.
160. Carbon steel, tempered, ½ x 2 inch.
161. Ditto, 1 x 1 inch.
162. Ditto.
163. Ditto.
164. Ditto.
165. Ditto.
166. Hard copper.
167. Hard brass.
168. Aluminium.
169. Bar brass on end.
170. Ditto.
171. Ditto, annealed.
172. Mild steel, hot-rolled.
173. Stellite.
174. Drill rod tension test-piece.
175. 1 per cent carbon steel, 1 inch diameter.
176. 1 per cent carbon steel, 1 inch diameter.
177. 1-inch drill rod on end.
178. High silicon spring steel.
179. Chrome steel, drawn, 480 deg. F.
180. Watch-case die carbon steel.
181. 5-16 inch cold-rolled steel.
182. 1.65 carbon steel, overheated.
183. Ditto, slightly overheated.
184. Ditto, unannealed, quenched below critical point.
185. 1.25 carbon steel, 1 x 1 inch, drawn.
185a. Ditto.
185b. Ditto.
186. Ditto.
188. 1.65 carbon steel, ½ x 1 inch, drawn.
189. 6 per cent nickel steel.
190. ⅞ x ⅞ inch square high-speed steel.
191. Chrome steel, annealed.
194. Manganese steel, ductile.
195. Chrome nickel steel.
196. Nickel steel, annealed.
197. 6 per cent nickel steel.
198. 2 per cent carbon steel.
199. ½ inch plate, copper.
200. Chrome nickel steel, ¾ x ¾ inch.
201. Vanadium steel, ¾ x ¾ inch.
202. 3½ per cent nickel steel.
203. Steel casting.
204. Ditto.
205. Silicon spring steel.
206. Ditto.
207. Vanadium steel.
208. Semi-high-speed steel.
209. High-speed steel inserted milling cutter blades.
201. Ditto.
211. Copper, ½ x ¾ inch.
212. Lead.
213. Brass, annealed, ½ x ½ inch.
214. ⅝-inch brass bar.
215. Chrome nickel.
216. Carbon, 1.75; tungsten, 1.75.
217. Nickel steel.
218. 62 per cent carbon.
219. 1.25 carbon, annealed.
220. Carbon, 1 per cent; chrome, 1 per cent.
221. 1 x 1 inch 1.25 carbon steel.
223. 1.34 carbon steel, 2 x 2 inch.
224. 1.24 carbon steel, 2 x 2 inch.
225. 1.75 carbon steel, tungsten.
226. High carbon chrome nickel steel.
227. High carbon chrome nickel steel.
228. Aluminium plate.
229. Carburised chrome nickel steel.
230. Vanadium steel, ½ x 1 inch.
231. Tin lead alloy.
233. Cast iron.
234. Ditto.
235. Ditto.
236. Ditto.
237. 1.25 carbon steel.
238. Ditto.
239. Ditto.
240. 1.65 carbon steel, ½ x 1 inch, overheated.
241. Vanadium steel, ½ x 1 inch, tempered.
242. Carburised chrome nickel.
243. Projectile steel chrome nickel, tempered.

## MONTREAL METALLURGICAL ASSOCIATION.

The December meeting of the Association was held on Tuesday, the 10th instant, at McGill University, and on that occasion an address was given by Professor Nevil Norton Evans on "The Meaning of Chemical Symbols and Equations." In the meetings of the Associaion it has been found that some members are not well acquainted with the usual chemical terms, and the lecture was intended to remedy this deficiency so that all may be prepared to enter fully into the discussions at the meetings.

# Phosphorous in Malleable Cast Iron

By J. H. TENG, M.Sc. (Bowen Research Scholar in Metallurgy in the University of Birmingham.)

English Iron and Steel Institute, Sept., 1918.

**Preliminary.**—In a paper read before the Birmingham Section of the Society of Chemical Industry, 1917, Professor Turner (¹)* urged the importance of employing, wherever possible, a poorer class of irons for making malleable castings than those hitherto used, in view of the heavy demand for purer irons for other purposes. The following investigations were undertaken to examine the effect of proportions of phosphorus varying from about 0.05 to 0.5 per cent. on the mechanical properties of malleable cast iron.

It has been stated by Ford (²) that irons containing more than 0.25 per cent. of phosphorus should not be used for malleable castings, or cracked and warped castings will result. An excess of phosphorus also reduces the melting point, and the castings are unable to resist the annealing temperatures, and show considerable oxidation.

According to Moldenke ([3]) the phosphorus content in the American Blackheart process does not exceed 0.225 per cent, although Touceda ([4]) has shown that a specimen containing 0.325 per cent. of phosphorus "is of good quality and sufficiently high grade to be suitable for any purpose for which malleable iron castings may be required." The experiments now to be described were undertaken at the suggestion of Professor T. Turner, and were conducted at the University of Birmingham.

Two series of test-bars were prepared: one by adding phosphoric iron to a very pure American washed white iron, and the other by adding the same to irons supplied by Messrs. Shutt and Ganderton, malleable ironfounders, Birmingham.

The composition of the American washed white iron was as follows:

| | P.C. | | P.C. |
|---|---|---|---|
| Combined carbon | 2.93 | Sulphur | 0.004 |
| Graphitic carbon | 0.15 | Phosphorus | 0.01 |
| Silicon | 0.01 | Manganese | nil |

This material is hard, white, and highly crystalline, and contains a considerable number of blowholes. The microstructure is typical of a white iron, consisting of pearlite and cementite. Seen under low magnifications, the pearlite is arranged in the finely marked dendritic form, in a ground-mass consisting of pearlite and cementite arranged as a eutectic.

On analysis the commercial irons yielded the following results:

| | White Iron. Per Cent. | Grey Iron. Per Cent. |
|---|---|---|
| Combined carbon | 2.670 | 0.440 |
| Graphitic carbon | 0.250 | 3.120 |
| Silicon | 0.560 | 2.200 |
| Sulphur | 0.325 | 0.036 |
| Phosphorus | 0.049 | 0.049 |
| Manganese | 0.160 | 0.580 |

The mixture used in preparing the second series of bars was one part grey and three parts white iron.

The phosphoric iron was prepared by adding red phosphorus to molten American washed white iron. It was hoped to obtain a 5 per cent. phosphorus-iron alloy, but owing to loss of phosphorus by volatilisation only a 4 per cent. alloy was secured. The iron was melted in a plumbago crucible, and a weighed quantity of phosphorus was well pressed into small burnt fireclay crucibles. The contents of each crucible were then emptied successively into the molten iron by holding the crucible mouth downwards, so that the rim of the crucible was well immersed in the molten metal. In this way the loss of phosphorus through volatilization was much minimized.

The haematite iron ore, used as the annealing medium, was ground to pass a ¾-inch riddle and then mixed with a certain amount of ore which had already been used as a packing material, the proportions of fresh and used ores being dependent on the cross-sectional area of the test-bars.

The following table shows the results of the chemical analysis of these ores dried at 100° C.:

| | Fresh Ore. Per Cent. | Used Ore. Per Cent. |
|---|---|---|
| Ferric oxide | 80.539 | 8.720 |
| Ferrous oxide | ...... | 58.560 |
| Silica | 16.880 | 18.000 |
| Alumina | 1.120 | 1.440 |
| Lime | 0.140 | 0.200 |
| Magnesia | 0.108 | 0.120 |
| Sulphur | 0.016 | 0.342 |
| Phosphorus | 0.012 | 0.017 |
| Manganese | 0.432 | 0.468 |
| Loss on ignition | 0.720 | ..... |
| Metallic iron | ..... | 12.105 |

Tensile, transverse, and bending tests were performed. The bars for tensile tests were circular in section: they were 9 inches long; 1½ inches at each end, had a diameter of 1 inch, and the 6 remaining inches at the middle had a diameter of ¾ inch. The bars for transverse tests were 10 inches long by 1 inch square. The bars for bending tests were 9 inches long by ½ inch square.

In both series duplicate bars were made in order to check the result of the testing, and also to replace bars which might contain blowholes or flaws.

The weight of each set of test-bars, consisting of two bars for tensile, two for transverse, and two for bending tests, were calculated to be about 11 lbs., and to allow for plenty of metal for the gates and runners, 20 lbs. of metal were allowed for each set of test-bars.

Owing to the difficulty of obtaining perfectly sound castings with the American washed iron, a small amount of a 25 per cent. ferro-silicon was added to all the casts forming the first series of the test-bars; the amount added was, however, not sufficient to give any trace of a mottled fracture to the bars. Further experiments have shown that about 0.25 per cent silicon is the greatest amount that can be added to this iron in the form of round bars of ¾ inch diameter without giving any trace of mottlings.

The weighed portion of American washed iron was melted in a plumbago crucible, and when thoroughly melted the calculated amount of ferro-silicon and phosphoric iron was added. After thorough stirring, the contents of the crucible were poured into greensand moulds. The bars were cast horizontally in pairs, a runner and a riser being provided for each pair. The melting and casting of all the bars were done under similar conditions. Representative samples of all the casts were obtained from the gate metals for analysis. The chemical analysis of the casts before annealing was as follows:

*Pure Iron Series.*

| Specimen. | Carbon. | Silicon. | Sulphur. | Manganese. | Phosphorus. |
|---|---|---|---|---|---|
| A | 2·83 | 0·20 | 0·0062 | nil | 0·01 |
| B | 2·83 | 0·21 | 0·0066 | ,, | 0·049 |
| C | 2·86 | 0·20 | 0·0070 | ,, | 0·110 |
| D | 2·82 | 0·22 | 0·0068 | ,, | 0·156 |
| E | 2·88 | 0·21 | 0·0064 | ,, | 0·208 |
| F | 2·88 | 0·22 | 0·0064 | ,, | 0·262 |
| G | 2·82 | 0·21 | 0·0070 | ,, | 0·309 |
| H | 2·80 | 0·19 | 0·0070 | ,, | 0·347 |
| I | 2·84 | 0·19 | 0·0068 | ,, | 0·412 |
| J | 2·85 | 0·22 | 0·0068 | ,, | 0·460 |
| K | 2·83 | 0·20 | 0·0067 | ,, | 0·512 |

The carbon contents in the above table are those of combined carbon, since no graphitic carbon was obtained.

It will be noticed from the above analysis, and the analysis of the American washed iron, that on re-

* The small numerals apply to refernces at end of paper.

melting this iron lost an average carbon content of 0.24 per cent. and gained an average sulphur content of 0.0027 per cent.

The common iron series of casts had the following chemical analysis before annealing:

*Common Iron Series.*

| Specimen. | Carbon. | Silicon. | Sulphur. | Manganese. | Phosphorus. |
|---|---|---|---|---|---|
| $T_1$ | 2·88 | 0·815 | 0·278 | 0·248 | 0·048 |
| $T_2$ | 2·80 | 0·810 | 0·273 | 0·245 | 0·106 |
| $T_3$ | 2·85 | 0·820 | 0·275 | 0·245 | 0·160 |
| $T_4$ | 2·82 | 0·820 | 0·278 | 0·248 | 0·208 |
| $T_5$ | 2·85 | 0·820 | 0·271 | 0·245 | 0·263 |
| $T_6$ | 2·90 | 0·816 | 0·272 | 0·247 | 0·300 |
| $T_7$ | 2·80 | 0·815 | 0·276 | 0·246 | 0·344 |
| $T_8$ | 2·78 | 0·818 | 0·270 | 0·246 | 0·406 |
| $T_9$ | 2·80 | 0·816 | 0·273 | 0·244 | 0·460 |
| $T_{10}$ | 2·77 | 0·816 | 0·275 | 0·245 | 0·525 |

The carbon contents in the above table are those of combined carbon, since no graphitic carbon was obtained.

**Microscopic Examnation of the Casts before Annealing.**—Representative samples of all the casts were obtained from the gate metals for microscopic examination.

The microstructure of all the specimens belonging to the first series of bars was characteristic of a white iron, consisting of bold and well-marked dendrites of pearlite in a ground mass of cementite. Figs 1 and 2, Plate I., are photomicrographs of specimens B and K respectively. One interestng feature observed in these microsections was that the cementite envelopes in the higher microsections was that the cementite envelopes in the higher phosphorus specimens appeared to be a little thicker than those in the lower phosphorus specimens.

The specimens belonging to the second series of bars were very similar, except that they showed globules of sulphides of iron and manganese, which did not appear in the first series. It appears that phosphorus increases the thickness of the cementite envelopes in white irons, irrespective of the chemical compositions at least so far as those white irons forming the subjects of these experiments are concerned.

**The Annealing Process.**—The bars having been barrelled to remove adhering sand were packed with haematite iron ore in two boxes, and owing to the different dimensions of the bars, the annealing mixture used was varied, in order to counteract the thickness of the different sections, since all the specimens were to be annealed in the same oven.

The following table shows the dimensions of the bars and the corresponding annealing mixture employed:

| Dimensions of Bar. | Annealing Mixture. | |
|---|---|---|
| | Fresh Ore. | Used Ore. |
| 1 inch × 1 inch × 10 inches. | 1 part | 2 parts |
| ¾ inch diameter × 9 inches. | 1 " | 3 " |
| ½ inch × ½ inch × 9 inches. | 1 " | 4 " |

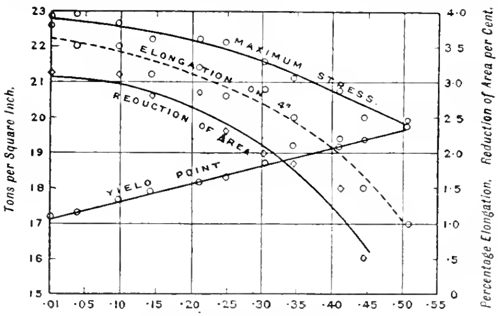
The boxes containing the bars were placed side by side and immediately beneath the thermal junction of a pyrometer, so that the temperature to which the bars were being subjected could be accurately known. The annealing oven was of the rectangular type, and had a capacity of about 12 tons. It was fired by gas generated in an underground chamber adjoining the oven. A mixture of coke and coal was employed to make the gas. The temperature of the annealing oven was slowly raised to 850° C., which temperature was kept up for four days; then it was raised to 900° C., and remained so for one day. The oven was then gradually cooled down to atmospheric temperature and the bars were withdrawn.

**Mechanical Testing of the Annealed Bars.**—All the bars were tested with the skin on. The results of the chemical and mechanical tests of the two series of bars are embodied in Tables I. and II. respectively.

**Tensile Tests.**—These tests were performed on a 50-ton horizontal machine. The maximum stress, elongation, and reduction of area are gradually lowered with increasing phosphorus, while the yield point is gradually raised. The most marked effects were observed in bars F. and $T_5$, having about 0.25 per cent. phosphorus, which show a distinct drop in the elongation and reduction. The bars belonging to the "Pure Iron Series" (Fig. 1) show a higher yield point but a lower maximum stress, a lower elongation, and a smaller reduction of area than those belonging to the "Common Iron Series" (Fig. 4). This difference in the mechanical properties between the two series of bars may be attributed to the influence of silicon, sulphur, and manganese which, up to a certain limit, tend to improve the material, quite apart from the fact that these elements have important effects on the annealing process.

**Transverse Tests.**—These tests were conducted on the horizontal tensile machine, the bars being supported between 8-inch centres. The load and the deflection were taken when the bars began to fracture Both the transverse strength and the deflection are steadily lowered with increasing phosphorus. In the "Pure Iron Series," the most marked effects are noticed in bar F, with about 0.25 per cent. phosphorus, which shows a considerable drop in the deflection (Fig. 2); while in the "Common Iron series" no serious drop is observed in the deflection until bar $T^6$ with about 0.3 per cent. phosphorus is reached (Fig. 5).

**Bending Tests.**—These tests were carried out on the horizontal tensile machine; the angle of bend in each case was measured when fracture took place. The bars were supported between 8-inch centres and were bent around a 1-inch round bar. The bending angle




*Phosphorus Per Cent.*

Fig.1.—Curves showing Effect of increasing Phosphorus on Tensile Properties. Pure Iron Series.

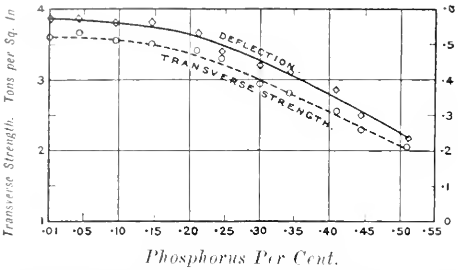



Fig. 2.—Curves showing Relation between Transverse Strength, Deflection, and Phosphorus. Pure Iron Series.

was progressively decreased with increasing phosphorus. Bars F and $T_5$ show a distinct decrease in the angle of bend, as compared with the preceding decreases.

**Hardness Tests.**—Sections were sawn off the bars in a direction at right angles to their lengths, and parallel surfaces were obtained by machining. These surfaces were ground down on emery-paper, then on a set of Hubert papers, and finally they were polished on chamois leather, using alumina. A Brinell testing machine was employed, giving a pressure of 3000 kilogrammes, and having a steel ball of 10 millimetres diameter. The portions being tested were at the centres of the sections, and the pressure being allowed to remain on the specimen for ten seconds in every case, so that the results obtained could be compared.

The influence of increasing phosphorus on the two series of specimens appears to be identical (Figs. 3 and 6). It increases the hardness steadily at first, and then much more rapidly. The last two specimens of the "Pure Iron Series," and the last three speci-

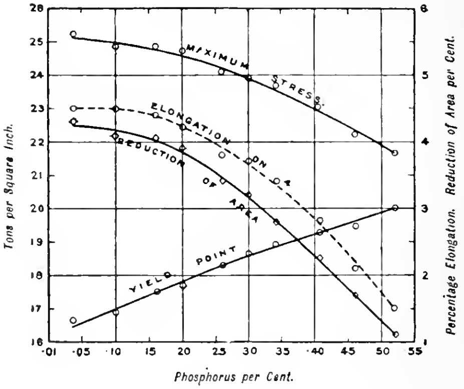



Fig. 4.—Curves showing effects of increasing phosphorus on tensile properties (common iron series.

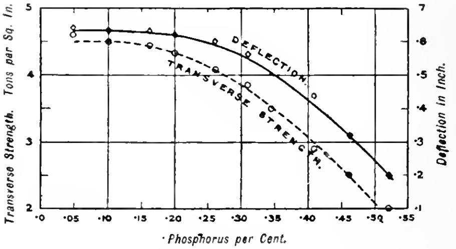



Fig. 5.—Curves showing relation between transverse strength, deflection and phosphorus (common iron series).

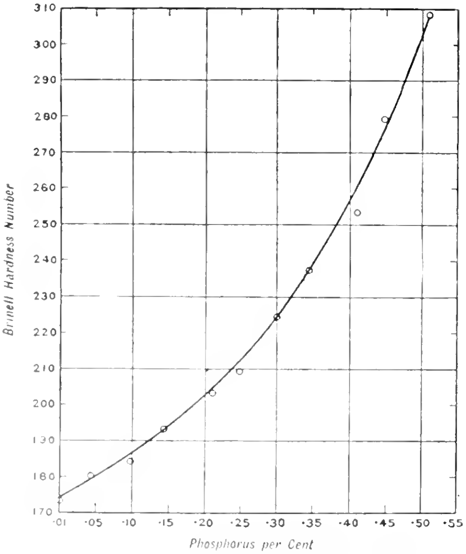



Fig. 3.—Phosphorus and Hardness. Pure Iron Series.

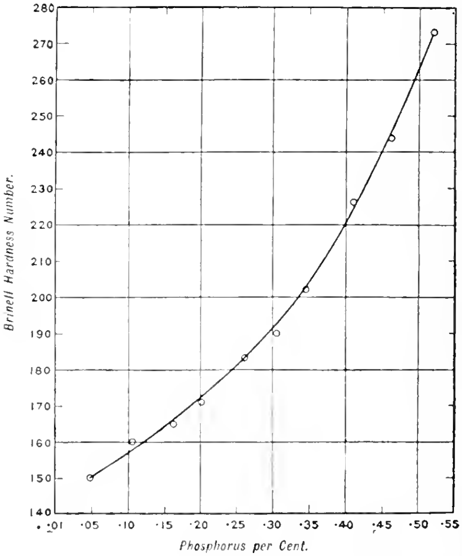



Fig. 6.—Phosphorus and Hardness. Common Iron Series.

mens of the "Common Iron Series" are decidedly harder than the preceding specimens. This sudden increase in the hardness may be attributed, at least to a certain extent, to the definite appearance of free phosphide of iron.

**Izod Impact Tests.** — Another series of test-bars was prepared for this test. The composition differed from that of the test-bars previously used, so as to confirm, as far as possible, the influence of phosphorus on the annealed specimens. The specimens were packed with iron oxide and annealed under ordinary conditions. The following table shows the results of the chemical tests of the specimens as cast and those of the impact tests of the annealed specimens:

| Mark on Specimen. | Carbon. | Silicon. | Sulphur. | Manganese. | Phosphorus. | Impact Tests. |
|---|---|---|---|---|---|---|
| | | | | | | Ft. Lbs. |
| $T_1$ | 2·96 | 0·586 | 0·442 | 0·208 | 0·06 | 8·5 |
| $T_2$ | 2·80 | 0·570 | 0·460 | 0·200 | 0·115 | 8·00 |
| $T_3$ | 2·92 | 0·585 | 0·454 | 0·195 | 0·165 | 7·25 |
| $T_4$ | 2·75 | 0·580 | 0·445 | 0·210 | 0·220 | 6·50 |
| $T_5$ | 2·80 | 0·575 | 0·440 | 0·201 | 0·258 | 6·00 |
| $T_6$ | 2·92 | 0·582 | 0·450 | 0·205 | 0·322 | 5·00 |
| $T_7$ | 2·70 | 0·580 | 0·430 | 0·199 | 0·362 | 4·25 |
| $T_8$ | 2·74 | 0·576 | 0·462 | 0·210 | 0·410 | 3·75 |
| $T_9$ | 2·92 | 0·580 | 0·452 | 0·204 | 0·465 | 3·00 |
| $T_{10}$ | 2·90 | 0·572 | 0·452 | 0·206 | 0·530 | 3·00 |

The section of the bars as cast was ½ inch square and, after annealing, they were machined down to ⅝ inch square. A V-shaped notch, having a depth of 1-20 of an inch was made on one side of all the specimens. The results of the impact tests again indicate the ill-effects of any addition of phosphorus.

**Microscopic Examination of the Annealed Bars.** — The structure of all the specimens belonging to the "Pure Iron Series" consists of ferrite, pearlite, and annealing carbon. The pearlite is rather massive, while the annealing carbon exists in a very fine state of division and is fairly uniformly distributed. From the centres towards the outer portions of the specimens the amount of pearlite and annealing carbon decreases, while the amount of ferrite increases until the rims of the specimens are reached, where ferrite alone exists. In the ferrite rims of all the specimens there exists a band of pearlite distinctly sandwiched between two layers of ferrite.

The structure of the specimens belonging to the "Common Iron Series" consists of ferrite, pearlite, and annealing carbon, and differs considerably from that observed in the "Pure Iron Series." In this series the amount of ferrite and annealing carbon is greater, and the amount of pearlite is smaller than those observed in the "Pure Iron Series." Furthermore, the carbon nodules are much bigger in the "Common Iron Series" than those in the "Pure Iron Series." Fig. 3, Plate I., is a photomicrograph of specimen $T_1$, and represents the general structure of the centres of all the specimens belonging to the "Common Iron Series." From the centres towards the outer portions of the specimens the amount of pearlite and annealing carbon decreases, while the amount of ferrite increases, until at the rims ferrite and sulphides of iron and manganese only exist. The annealing carbon at the centre of each section and the manganese and iron sulphides throughout the entire section are fairly uniformly distributed in all the sections. Here, again, a band of pearlite exists in the ferrite rims of all the specimens. According to Hatfield ([5]) this band of pearlite does generally occur in a greater or lesser degree in all blackheart malleable castings. It is thus interesting to record that this band of pearlite also occurs in the ferrite rims of the European whiteheart malleable castings. As suggested by Hatfield, it is possible that if the carbon monoxide, produced by the decomposition of the carbide, preponderates, a recarburisation might have taken place, but as a matter of fact this outer ring of pearlite is frequently met with in annealed castings that have had throughout their heat treatment an oxidising atmosphere.

Deep etching of the specimens reveals the gradual increase in the size of the crystal grains as we pass from the poor to the rich phosphorus alloys. Thus one effect of phosphorus is to increase the size of the crystal grains.

**Appearance of the Fractures of the Bars used for Bending and Transverse Tests.**—The fractures of the bending and transverse bars showed peculiar appearances. The fractures of the low phosphorus content bars were partly dull and apparently amorphous, and partly crystalline, while those of the high phosphorus content bars were wholly crystalline. Closer observation revealed the fact that the portions of the low phosphorus content bars, which were subjected to compression, showed a more or less crystalline appearance, while those portions which were subjected to tension showed a dull appearance. This contrast of the appearance of the fractures of the bars gradually disappeared as the phosphorus content increased.

This peculiarity of the fractures led the author to secure a number of specimens from some local works, in order to see, by the appearance of their fractures, whether it was entirely due to the influence of phosphorus or to some other factors as well, with the result that some interesting data were obtained.

Three specimens were obtained from three different local works, and they analysed as follows:

| Specimen. | C.C. | G.C. | Si. | S. | P. | Mn. |
|---|---|---|---|---|---|---|
| *a* | 1·20 | 0·75 | 0·780 | 0·328 | 0·048 | 0·210 |
| *b* | 0·76 | 1·26 | 0·541 | 0·164 | 0·049 | 0·288 |
| *c* | 0·62 | 1·45 | 0 648 | 0·247 | 0·065 | 0·365 |

These specimens, which were nearly of the same thickness, were fractured on the vice by bending around a 1-inch round bar, and the fractures examined. Results of bending tests:

| Specimen. | Bending Angle. |
|---|---|
| a | 45° |
| b | 80° |
| c | 150° |

The result of these tests, although not strictly comparable, since the sections of the specimens are not exactly the same, are nevertheless a measure of the malleability of the specimens.

The results of the examination of the fractures of the specimens is shown in the following table:

| Specimen. | Appearance of Fracture. | |
|---|---|---|
| | Compression Side. | Tension Side. |
| *a* | Slightly crystalline | Dull |
| *b* | More crystalline | " |
| *c* | Highly crystalline | " |

PLATE I.

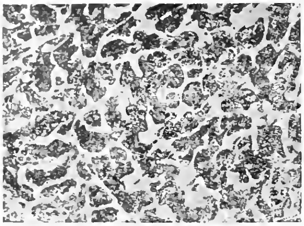


Fig. 1.
Test Bar as cast (hard white iron).

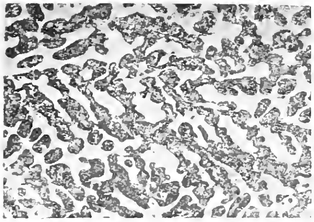


Fig. 2.
Test Bar as cast (hard white iron).
Etched with picric acid.

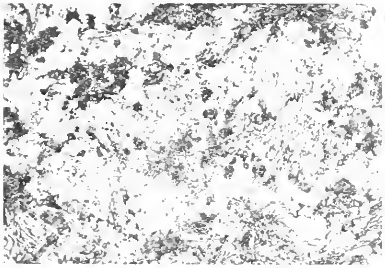
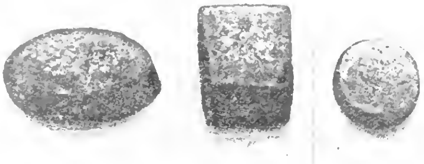


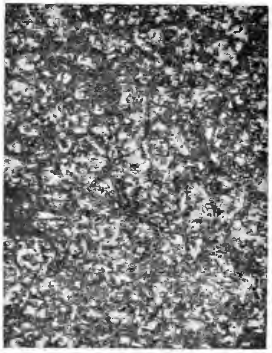
Fig. 3.—Annealed Bars, showing ferrite, pearlite and annealing carbon. Etched with picric acid. x 100.



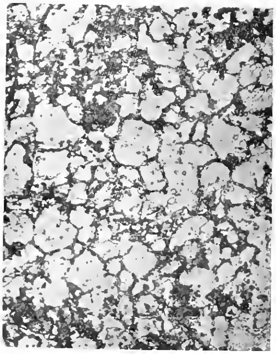
A B C
Fig. 4.—Fractures of Common Iron Series.

PLATE II.

T. 1.
Fi7. 5.



T. 5.
Fig. 6.



T. 10.
Fig. 7.

Annealed Bars treated with Dr. Stead's cupric reagent x 100.

*ANNEALED BARS, TREATED WITH DISTEAD'S CUPRIC REAGENT.* 100.

**TABLE I.**—*Chemical and Mechanical Tests of the Annealed Bars. Pure Iron Series.*

| Mark on Specimen | A. | B. | C. | D. | E. | F. | G. | H. | I. | J. | K. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Combined carbon | 0·86 | 0·84 | 0·80 | 0·88 | 0·90 | 0·85 | 0·85 | 0·80 | 0·89 | 0·90 | 0·83 |
| Graphitic carbon | 1·12 | 1·08 | 1·10 | 1·20 | 1·09 | 1·10 | 1·20 | 1·15 | 1·11 | 1·20 | 1·16 |
| Silicon | 0·204 | 0·208 | 0·210 | 0·204 | 0·202 | 0·210 | 0·205 | 0·204 | 0·200 | 0 210 | 0·206 |
| Sulphur | 0·007 | 0·006 | 0·007 | 0·006 | 0·006 | 0·007 | 0·008 | 0·007 | 0·007 | 0·006 | 0·008 |
| Manganese | nil | nil | nil | nil | nil | nil | nil | nil | nil | nil | nil |
| Phosphorus | 0·010 | 0·046 | 0·096 | 0·144 | 0·210 | 0·218 | 0·302 | 0·345 | 0·412 | 0·446 | 0·508 |
| Yield point, tons per square inch | 17·20 | 17·30 | 17·65 | 17·90 | 18·20 | 18·35 | 18·70 | 19·20 | 19·20 | 19·40 | 19·80 |
| Maximum stress, tons per square inch | 22·85 | 22·90 | 22·54 | 22·20 | 22·20 | 22·10 | 21·56 | 21·15 | 20·75 | 20·10 | 19·95 |
| Elongation per cent. on 4 inches | 3·8 | 3·5 | 3·5 | 3·1 | 3·2 | 2·8 | 2·9 | 2·5 | 2·2 | 1·5 | 1·0 |
| Reduction of area per cent. | 3·12 | 3·00 | 3·10 | 2·80 | 2·85 | 2·30 | 2·00 | 1·85 | 1·5 | 0·50 | nil |
| Transverse strength, tons per square inch | 3·6 | 3·67 | 3·55 | 3·50 | 3·40 | 3·29 | 2·95 | 2·80 | 2·55 | 2·30 | 1·80 |
| Deflection in inch | 0·57 | 0 57 | 0·56 | 0·56 | 0·53 | 0·48 | 0·44 | 0·42 | 0·37 | 0·30 | 0·18 |
| Angle of bend | 60° | 62° | 58° | 61° | 55° | 45° | 45° | 40° | 30° | 20° | nil |
| Brinell hardness number | 173 | 180 | 184 | 193 | 203 | 209 | 224 | 237 | 253 | 279 | 308 |

Drillings for chemical analysis were taken through the middle of all the bars.

**TABLE II.**—*Chemical and Mechanical Tests of the Annealed Bars. Common Iron Series.*

| Mark on Specimen | $T_1$. | $T_2$. | $T_3$. | $T_4$. | $T_5$. | $T_6$. | $T_7$. | $T_8$. | $T_9$. | $T_{10}$. |
|---|---|---|---|---|---|---|---|---|---|---|
| Combined carbon | 0·44 | 0·49 | 0·40 | 0·49 | 0·50 | 0·45 | 0·48 | 0·50 | 0·52 | 0·54 |
| Graphitic carbon | 1·76 | 1·72 | 1·75 | 1·62 | 1·65 | 1·70 | 1·62 | 1·60 | 1·58 | 1·59 |
| Silicon | 0·815 | 0·810 | 0·817 | 0·815 | 0·818 | 0·818 | 0·810 | 0·818 | 0·816 | 0·816 |
| Sulphur | 0·278 | 0·272 | 0·275 | 0·275 | 0·269 | 0·274 | 0·276 | 0·272 | 0·275 | 0·275 |
| Manganese | 0·245 | 0·245 | 0·248 | 0·249 | 0·246 | 0·245 | 0·248 | 0·248 | 0·244 | 0·246 |
| Phosphorus | 0·048 | 0·106 | 0·160 | 0·200 | 0·261 | 0·306 | 0·346 | 0·408 | 0·461 | 0·520 |
| Yield point, tons per square inch | 16·65 | 16·90 | 17·55 | 17·70 | 18·30 | 18·60 | 18·90 | 19·35 | 19·45 | 20·00 |
| Maximum stress, tons per square inch | 25·20 | 24·85 | 24·80 | 24·65 | 24·10 | 23·90 | 23·65 | 23·00 | 22·20 | 21·65 |
| Elongation per cent. on 4 inches | 4·5 | 4·5 | 4·4 | 4·2 | 3·8 | 3·7 | 3·4 | 2·8 | 2·1 | 1·5 |
| Reduction of area per cent. | 4·3 | 4·1 | 4·05 | 3·9 | 3·42 | 3·22 | 2·8 | 2·25 | 1·7 | 1·1 |
| Transverse strength, tons per square inch | 4·59 | 4·50 | 4·45 | 4·35 | 4·10 | 3·85 | 3·5 | 2·9 | 2·5 | 2·00 |
| Deflection in inch | 0·64 | 0·63 | 0·63 | 0·62 | 0·60 | 0·56 | 0·50 | 0·44 | 0·32 | 0·20 |
| Angle of bend | 80° | 74° | 75° | 70° | 62° | 55° | 45° | 40° | 30° | 25° |
| Brinell hardness number | 150 | 160 | 165 | 171 | 183 | 190 | 202 | 226 | 244 | 273 |

Drillings for chemical analysis were taken through the middle of all the bars.

Fig. 4, Plate I., are photographs of the fractures of these specimens, slightly magnified. It will be seen in these photographs that the crystalline portion of specimen c occupies a greater area than the portions of either specimen a or b. It appears that the more malleable the specimen, the greater will be the contrast in appearance between the compression and tension sides. This is due to the greater amount of ferrite. A consideration of the behaviour of the crystals of a ductile material, which is partly under tension and partly under compression, will at once show that the results of the above observations are to be expected. The crystals on the tension side are drawn out, so to speak, at their ends; while those on the compression side will be flattened out. and having a certain amount of soft material to fall back upon these crystals will show their crystalline faces in a direction at right angles to which the force is applied.

It is thus apparent that a hard and brittle material when fractured by bending will not exhibit the characteristic combination of crystalline and dull fracture. Here an explanation may be found for the wholly crystalline fractures of the high phosphorus content bars above referred to. The results of the mechanical tests of the bars appear to support this view.

**Copper Deposition Examination.**—In order to reveal the distribution of phosphorus in the annealed bars, sections after careful repolishing were treated by Dr. Stead's cupric reagent. (6) The reagent was dropped on each section until the section would hold no more, and then allowed to stand for two minutes. The sections were all treated alike and for the same period. After washing the sections with boiling water, and then with methylated spirit, they were carefully dried and examined under the microscope.

Results of micro-examination of sections belonging to the "Pure Iron Series":

From sections A to K the thickness of the copper deposits decreased gradually, while the proportions of the number of areas which remained bright steadily increased. The ferrite in the immediate vicinity of the annealing carbon nodules remained bright. But as the phosphorus increased, some of the ferrite also received a copper deposit.

Sections belonging to the "Common Iron Series" also showed a progressively decreasing thickness of copper deposit from section $T_1$ to section $T_{10}$. Here again the ferrite in contact with the annealing carbon nodules was free of copper deposit, and as the phosphorus contents increased, some of the ferrite was also covered with copper. Figs. 5, 6 and 7, Plate II., are photomicrographs of sections $T_1$, $T_5$, and $T_{10}$, respectively, and show the manner in which the copper deposition has taken place. In both K and $T_{10}$ the copper has deposited in such a way as to suggest the demarcation of crystal boundaries.

It was thought that oxidation had taken place in the high phosphorus content specimens, and that the oxide of iron so formed in the crystal boundaries led

to the deposition of copper in these areas. Specimen T[illegible] containing the highest phosphorus content in the "Common Iron Series," was therefore heated at a temperature of about 750°C. for 42 hours in a stream of coal-gas, the cooling taking place in the same gas. After this heat treatment the specimen was repolished and treated with the cupric reagent in exactly the same manner as before. No difference in the copper deposition was observed, and hence it would seem that the peculiar way in which the copper has deposited on the high phosphorus content specimens is not due to the oxidation of the specimens, but must be attributed to the distribution of the phosphorus.

**Presence of Sulphide of Iron in Spent Ore.**—An attempt was made to trace the origin of the sulphide of iron which is invariably found in the iron ore that has been used as the annealing medium in the production of malleable castings. Mr. R. H. Smith (7) has indicated that the white irons which are being annealed in an iron ore do not lose their sulphur contents, no matter whether these irons contain a low or high sulphur content. Hence the origin of the iron sulphide must be sought for elsewhere. The sulphur content of the fresh ores generally used in this district does not exceed about 0.02 per cent., whereas the sulphur content of the used ores sometimes reach to 0.3 or 0.4 per cent. In the earlier part of the present paper the analyses of the fresh and used ores were given, from which it will be seen that the sulphur content of the fresh ore is 0.016 per cent., while that of the used ore is 0.342 per cent. Subsequent analysis has shown that 0.096 per cent. of the sulphur in the used ore exists as sulphide of iron. Professor Turner concluded that the presence of this sulphide was derived from the action of the reducing gases existing in the furnace at a temperature of about 900° C. The following experiments were undertaken in order to see whether this sulphide of iron was really due to the reducing character of the atmosphere in the annealing furnace. Pieces of very pure American washed white iron and of common sulphurous white iron were packed with fresh haematite iron ore in two separate fireclay crucibles. The lids having been luted on the crucibles, they were placed in an oxidising annealing muffle-furnace, and a temperature of 900° C. was maintained for 72 hours. After the heat treatment the ore was ground down to a fine state of division and found to be magnetic. Minute pieces of metallic iron, which had been apparently flattened out by the grinding, could be seen.

The ore was analysed for sulphide of iron and metallic iron. No trace of sulphide of iron could be found, although 1.56 and 1.42 per cent. of metallic iron were obtained from the two samples of ore respectively. These results appear to show that no sulphide of iron is formed in the spent ore when the atmosphere of the annealing furnace is oxidising in character.

In order to confirm the laboratory results, samples of gases in the works annealing furnace were obtained at a temperature of 900° C. Two samples were obtained, one at 11 a.m., and the other at 4 p.m. on the same day. Results of the gas analyses:

| | Sample I. | Sample II. |
|---|---|---|
| | Per Cent. | Per Cent |
| Carbon dioxide | 14·17 | 12·30 |
| Carbon monoxide | 6·78 | 7·42 |
| Oxygen | 4·00 | 3·45 |
| Hydrogen | 2·12 | 2·86 |
| Methane | 0·58 | 0·75 |
| Sulphur compounds | 0·20 | 0·25 |
| Nitrogen | 72·15 | 72·97 |
| Heavy hydrocarbons | nil | nil |
| | 100·00 | 100·00 |

The results of the analyses of the two samples of furnace gases appear to support Professor Turner's view with regard to the origin of sulphide of iron in the spent ore. It should be mentioned that these samples of gases were not obtained inside the boxes where the bars were embedded, but an explanation may be found for the action of these gases upon the annealing oxide. It is certainly probable that the luting material, with which the boxes were rendered air-tight, gave way at the high temperature of the annealing furnace—thus portions of it were detached or cracked—and that the furnace gases obtained access to the boxes in which the castings were embedded.

## Conclusions.

From the results of the foregoing experiments the following conclusions may be drawn:

1. The addition of phosphorus does not result in any improvement in the mechanical properties of the malleable casting.
2. Any addition of phosphorus leads to a deterioration in the mechanical properties, as shown by tenacity, elongation, etc.
3. The ill effects of phosphorus do not become marked until about 0.2 per cent. of phosphorus has been reached, and this may be considered to be the approximate limit for commercial purposes.
4. That the presence of a considerable amount of silicon and manganese is of more importance than the absence of sulphur with regard to the success of the annealing operation.
5. That the origin of the sulphide of iron in the spent oxide is attributable to the presence of sulphur compounds in the reducing atmosphere existing in the annealing furnace at about 900° C.

The author wishes to tender his most sincere thanks to Professor Turner for his kind advice and criticism in the prosecution of the work, and his indebtedness to the following firms for facilities in the preparation and annealing of the test-bars; Messrs. Baker's Foundry Company, Malleable Ironfounders, Smethwick; Messrs. Shutt & Ganderton, Malleable Ironfounders, Birmingham; and Messrs. Vowles Brothers, General Ironfounders, West Bromwich. He is also grateful to Professor F. C. Lea, of the Civil Engineering Department, for permission to make use of his testing machines in the Bournbrook Buildings.

## References.

1. T. Turner: "The Metal Industry," August 10, 1917, p. 103.

2. H. Ford: "Malleable Iron Castings," Proceedings of the British Foundrymen's Association, 1913-14, p. 176.

3. R. Moldenke: "The Production of Malleable Castings," 1911, p. 72.

4. E. Touceda: Journal of the American Foundrymen's Association, September 28, 1915.

5. W. H. Hatfield: "Cast Iron in the Light of Recent Research," p. 197.

6. J. E. Stead: Journal of the Iron and Steel Institute, 1915, No. 1, p. 173.

7. R. H. Smith: Journal of the Iron and Steel Institute, 1915, No. 11, pp. 142-52.

## HAMILTON NOTES.

### Manufacturing Conditions in Hamilton as Affected by the Armistice.

The news of peace was welcomed in Hamilton with the deepest joy and thankfulness, and externally with the wildest demonstrations, processions with floats, etc., from the different manufacturers that had been preparing to advertise the Victory Loan. In spite of the heartfelt thankfulness that everyone felt, there was with many a good deal of anxiety as to immediate future conditions; this was perhaps especially so amongst those employed on munition work.

This fear has proved almost entirely groundless, as practically all the men who have been laid off owing to the stoppage of war contracts, have been absorbed by other concerns who have been short handed or are increasing their staff of employees. The Steel Co. of Canada, The International Harvester Co., The Oliver Chilled Plow Works, all report that they are taking on men, and indeed still find a labor shortage. A number of men in almost every factory will be discharged on account of their inefficiency as soon as their places can be filled by more competent men, but it does not seem probable that even this can be done immediately.

There have been reports of a wholesale discharge of employees from certain plants, but these are denied. A few of the plants engaged largely on munitions have discharged some men whom they could not work into other departments, but these plants expect shortly to have made the change from war work to some steady line of manufacture. The Canadian Cartridge Co. have already made this change, for they are now manufacturing steel barrels, the new building they recently erected having been put up with that object in view.

It is hoped that the manufacturing plants that are now working on regular lines will be able to handle all unemployed labour for the time being, and this is probable, as labour has been so extremely scarce up to the time of signing the armistice. It is probable that by the time the men start to return from overseas, the larger plants will have made the necessary changes of equipment and organization to handle standard lines of work, and that these will be largely operated by returning men.

The manufacturers of farm implements, such as Sawyer and Massey, International Harvester Co., and Oliver Plow Works, are looking forward to the future, as Mr. Palmer, of Sawyer and Masseys, put it, with a feeling of optimism. This is on account of the hope of increased home trade, and of expectation of increased shipping facilities for export trade.

Some industries, such as the National Steel Car Co., the Burlington Steel Co., and the Hamilton Bridge Works Co., expect to be very little affected by the new conditions, but the position of these firms will depend largely on the attitude of the Government with regard to the control of steel and steel prices.

The National Steel Car Co. report large orders on hand, and have good expectations for the future. The Steel Co. of Canada do not expect that the change will affect them seriously. They were really out of the shell business, and though they have now stopped making shell steel, there is a large demand for other kinds of steel, which will absorb their whole output.

It is not thought that the iron foundries will be much affected by the change to peace conditions, but it is feared that the small machinists, who have been employed on punch and die work for the large concerns may be rather slack for a time, but taken all around, conditions are thought to be much better than was at first anticipated, although much must still be left to conjecture. It is hoped that after two or three weeks more conditions will have become steady, and that by that time a number of plants will have completed the necessary changes for peace work, and that industrial life will then be running smoothly once more.

---

In our last issue we had the sad duty of recording the death of Mrs. Carl Snyder, on Oct. 21st. Before the end of that week, we heard of the death of her eldest son, Harry, and the same day Mr. Snyder himself was taken to the hospital, dying the following day. Four children are left. Mr. Snyder was about 37 years of age, a native of Sharon, Pa. He began his business career with The Carnegie Steel Co., was later identified with The Passiac Steel Co., and came to Hamilton about thirteen years ago to accept a position with the old Hamilton Steel and Iron Co., Ltd., later absorbed by the Steel Co. of Canada, Ltd. Mr. Snyder, who was Assistant Accountant at the Steel Co., left this city last July to accept the position of Assistant General Supt. of the Buffalo Bolt Works. It is seldom that such particularly sad circumstances are met with, and the many friends of the family feel the bereavements very much.

The influenza, which was very severe in Hamilton last month, but was virtually checked by the beginning of November, has broken out again with renewed violence. The Peace celebrations and the lifting of the ban from public meetings and amusements are blamed for the second outbreak. Some manufacturers have had their employees inoculated, but, in addition to the serious mortality, considerable inconvenience has been caused by the attack in the various plants and factories.

---

The Oliver Chilled Plow Works report orders sufficient to keep their plant running at full capacity all through the year 1919. They are taking on more men and believe the prospects ahead are bright. This firm does a large export business, as well as that for home markets; just at present they are shipping implements to England, France and South America, while their regular export trade covers Norway, Australia and other parts.

Mr. Clark Madgett, who for some time has been Sales Engineer for The Standard Steel Construction Co. of Welland, Ont., with headquarters at Hamilton, has been appointed to the position of Assistant Manager, and has been moved to Welland. Mr. Madgett is to be congratulated on his success since he has been connected with this company.

---

The Steel Company of Canada has put the first unit of the new coke ovens into operation. The first coke was turned out about Nov. 18th, and is pronounced to be of excellent character. There are to be two units, each comprising forty ovens.

---

The Steel Company of Canada expect to install additional sets of rolls in their Billet Mill some time next month, probably during the holiday season, as it will entail shutting down the mill for a few days. At present the Billet Mill, which is really a continuation of the Blooming Mill, receives a 4'' by 4'' billet from the Blooming Mill, and breaks it down to a one and three-quarters by one and three quarters billet, passing it on live rolls through a flying shear, where it is cut to length, and depositing the sheared lengths on a hot bed under the Yard Crane Runway, from which these billets are transferred to the rod mill or any of the other mills desired, where they are again broken down to smaller sizes. The new rolls will be placed between the last rolls of the present billet mill and the flying shear, the old and new rolls together forming one continuous billet mill.

---

The building of the Canadian Westinghouse Co. on Aberdeen Ave., that has been occupied for many months, by the military authorities, will soon be empty once more; as demobilization of the R.A.F., which has been using it as an Armament School, has already commenced. The building, which was erected by the Westinghouse for a foundry, and never put into operation, has proved most useful for military purposes.

---

# The Allied Metals Congress

## THE ALLIED METALS CONGRESS.

In our last issue we gave an account of the joint congress held at Milwaukee by the American Institute of Mining Engineers, the American Foundrymen's Association and the American Malelable Castings Association. We print herewith a list of the papers that we presented at the Congress.

### PAPERS PRESENTED AT A. I. M. E. SESSIONS.

"**The Metallography of Tungsten,**" By Zay Jeffries, Aluminum Casting Co., Cleveland. ("Bulletin" No. 138, p. 1037.)

"**The Constitution of the Tin Bronzes,**" by S. L. Hoyt, University of Minnesota, Minneapolis.

Paper, title not given, by C. H. Matthewson, Sheffield Scientific School, Yale University, New Haven, Conn.

"**Notes on Babbitt and Babbitted Bearings,**" by Jesse L. Jones, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. ("Bulletin" No. 140, p. 1397.)

"**Oxygen and Sulphur in the Melting of Copper Cathodes,**" by S. Skowronski, Raritan Copper Works, Perth Amboy, N. J. ("Bulletin" No. 135, p. 645); with discussion by Philip L. Gill.

"**The Relation of Sulphur to the Overpoling of Copper,**" by S. Skowronski. ("Bulletin" No. 135, p. 6091), with discussion by Philip L. Gill, metallurgical engineer, 40 Cedar street, New York. ("Bulletin" No. 140, p. 1156.)

"**The Volatility of the Constituents of Brass,**" by John Johnston, American Zinc, Lead and Smelting Co., St. Louis. ("Journal American Institute of Metals," March, 1918, p. 15.)

"**Notes on the Metallography of Aluminum,**" by P. D. Mercia, Bureau of Standards, Washington, D. C., and J. R. Freeman, Jr.

"**The Effect of Impurities on the Hardness of Cast Zinc or Spelter,**" by G. C. Stone, New Jersey Zinc Co., New York. ("Journal American Institute of Metals," March, 1918, p. 11.)

"**Dental Alloys,**" by Dr. Arthur W. Gray, L. D. Caulk Co., Milford, Del.

"**Electrolytic Zinc,**" by C. A. Hansen, General Electric Co., Salt Lake City, Utah. ("Bulletin" No. 135, p. 615.)

"**The Condensation of Zinc From Its Vapor,**" by C. H. Fulton, Case School of Applied Science, Cleveland. ("Bulletin" No. 140, p. 1375.)

"**The Action of Reducing Gases on Copper,**" by Norman B. Pilling. ("Bulletin" No. 142, Sept., 1918.)

Symposium on "**The Conservation of Tin.**" This topic was discussed by the following: C. W. Thompson, National Lead Co., New York; G. H. Clamer, Ajax Metal Co., Philadelphia; C. M. Waring, Pennsylvania Railroad Co.; M. L. Lissberger, Mark Lissberger & Son, Inc., Long Island City, N. Y.; D. M. Buck, American Sheet & Tin Plate Co., Pittsburgh; W. M. Corse, Buffalo; G. K. Burgess and Mr. Woodward, United States Bureau of Standards, Washington, D. C.; M. L. Dizer, War Industries Board, Washington, D. C.; Jesse L. Jones, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

"**Notes on Non-Metallic Inclusions in Bronzes and Brasses,**" by G. F. Comstock, Titanium Alloy Mfg. Co., Niagara Falls, N. Y. ("Journal American Institute of Metals," March, 1918, p. 5.)

"**Nichrome Castings,**" by Arlington Bengal, Driver-Harris Wire Co., Harrison, N. J.

"**Fusible Plub Manufacture,**" by G. K. Burgess and L. J. Gurevich, Bureau of Standards, Washington, D. C.

"**Application of the Spectroscope to the Chemical Determination of Lead in Copper,**" by Messrs. Hill and Lucke.

"**Radium,**" by Richard B. Moore, United States Bureau of Mines, Golden Colo. ("Bulletin" No. 140, p. 1165.)

"**The Work of the National Research Council,**" by Henry M. Howe, chairman, Engineering Division, National Research Council, Washington, D. C.

"**The Limonite Deposits of Mayaguez, Mesa, Porto Rico,**" by C. R. Fettke, Carnegie Institute of Technology, Pittsburgh, and Be la Hubbard. ("Bulletin" No. 135, p. 661.)

"**The Manufacture of Ferro Alloys in the Electric Furnace,**" by R. M. Keeney, Ferro Alloy Co., Denver, Col. ('Bulletin" No. 140, p. 1321.)

"**The Manufacture of Silica Brick,**" by H. LeChatelier, Paris, France, and B. Bogitch. ("Bulletin" No. 141, Sept., 1918.)

"**Notes on Certain Iron Ore Resources of the World,**" New York Section Meeting of May 23, 1918. ("Bulletin" No. 141, Sept., 1918.)

"Recent Geologic Development on the Mesabi Iron Range, Minn." Discussion by Anson A. Betts, Anson A. Betts & Co., Ashland, N. C., and J. F. Wolff, Oliver Iron Mining Co., Duluth. ("Bulletin" No. 141, Sept., 1918.)

Moving Pictures on the Triplex Steel Process.

"The By-product Coke Oven and Its Products," by W. H. Blauvelt, Syracuse, N. Y. ("Bulletin" No. 135, p. 597.)

"The Use of Coal in Pulverized Form," by H. R. Collins, Fuller Engineering Co., Allentown, Pa. ("Bulletin" No 136, p. 955.)

"Carbocoal," by C. T. Malcolmson, Malcolmson Briquet Engineering Co., Chicago. ("Bulletin" No. 137, p. ....)

"Low-temperature Distillation of Illinois and Indiana Coals." by G. W. Traer, Universal Coal Products Co., Chicago. ("Bulletin" No. 141, Sept., 1918.)

"Price Fixing of Bituminous Coal by the U. S. Fuel Administration," by Cyrus Garnsey, R. V. Norris and J. H. Allport. ("Bulletin" No. 141, Sept., 1918.)

---

## PAPERS PRESENTED AT AMERICAN FOUNDRYMEN'S ASSOCIATION SESSIONS.

"Selecting the Sand-Blast Equipment for the Foundry," by H. D. Gates, Pangborn Corp., Hagerstown, Md.

"Engineers—Their Relation to the Foundry in the Saving of Labor," by E. S. Carman, Cleveland Osborn Mfg. Co., Cleveland.

"Women in the Foundry," by C. E. Knoeppell, C. E. Knoeppel & Co., New York.

"Cottrell Precipitation Process and Its Application to Foundry Dust Problems," by H. D. Egbert, Research Corp., New York.

"The Commerce of Coke," by J. A. Galligan, Pickands, Brown & Co., Chicago.

"Sale and Distribution of Foundry Pig Iron in War Times," by C. J. Stark, editor "The Iron Trade Review, Cleveland."

"Ferruginous and Other Bonds in Molding Sands," by Prof. P. S. H. Boswell, Imperial College of Science and Technology, South Kensington, London, Eng.

"What the State Can Do to Prevent Accidents," address by Hon. Thomas J. Duffy, chairman, Industrial Commission of Ohio, Columbus, O.

"Accident Prevention is Good Business," by Fred M. Wilcox, vice-president, Industrial Commission of Wisconsin, Madison, Wis.

Report of the American Foundrymen's Association committee on Safety, Sanitation and Fire Prevention, by Victor T. Noonan, chairman, Director of Safety, Industrial Commission of Ohio, Columbus, O.

"Problems of the Returned Soldiers," by W. A. Janssen, Canadian Steel Foundries, Ltd., Montreal, Que.

"The Personal Interest of the Employer is Necessary in Accident Prevention," by Victor T. Noonan.

"The Vital Importance of Industrial Accident Prevention in War Times," by Victor T. Noonan.

"An Accident Prevention Campaign in an Open-Hearth Steel Foundry With the Aid of Safety Committees," by F. G. Bennett, Director of Safety, Buckeye Steel Castings Co., Columbus, O.

"Cause and Prevention of Industrial Accidents," moving pictures to be shown, by Victor T. Noonan.

"Safety and Efficiency, Facts and Figures," by C. W. Price, field secretary, National Safety Council, Chicago.

"The Continuous Two-Story Foundry," by J. F. Ervin, Michigan Motor Castings Operating Co., Flint, Mich.

"Organizing a Foundry for the Economical Production of Gray Iron Castings," by Paul R. Ramp, Campbell, Wyant & Cannon, Muskegon, Mich.

"Cast Iron in Service Projectiles and Trench Warfare," address by Major Edgar Allen Custer, Pittsburgh District Ordnance Department, Pittsburgh.

"The Use of Positive Displacement Blowers in Cupola Practice," by W. Trinks, Carnegie Institute of Technology, Pittsburgh.

"Recent Developments in Burning Oil in Cupolas," by John Howe Tall, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

Report of A. F. A. Committee on General Specifications for Gray Iron Castings, by Richard Moldenke, Watchung, N. J.

"A Rapid Method for the Determination of Graphitic Carbon," by Frank H. Kingdon, Sullivan Machinery Co., Claremont, N. J.

"Malleable Iron as a Material in Engineering Construction," by H. A. Schwartz, National Malleable Castings Co., Indianapolis, Ind.

"Experiments in Annealing Malleable Iron," by H. E. Diller, General Electric Co., Erie, Pa., with written discussion by P. Dressler, American-Dressler Tunnel Kilns Co., New York.

"A Modern Core Room," by Donald S. Barrows, T. H. Symington Co., Rochester, N. Y.

"Some Factors in the Manufacture of High Grade Malleable Iron Castings," by J. G. Garrard, Northwestern Malleable Iron Co., Milwaukee.

"The Integrity of the Castings," by Enrique Touceda, consulting engineer, Albany, N. Y.

Report of the A. F. A. Committee on Specifications for Malleable Iron Castings, by Enrique Touceda, Albany, N. Y.

"Advantages of Malleable Iron Versus Steel for Agricultural Castings," by P. A. Paulson, Rockford Malleable Iron Co., Rockford, Ill.

"Ordnance Steel for the Army and Navy," by John Howe Hall, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

"Meeting Specifications for Army Ordnance Steel Castings," by Capt. E. R. Swanson, Ordnance Department, Inspection Division, Washington, D. C.

Tropical discussion of ordnance stel problems will follow the presentation of the two foregoing papers.

"Making Steel Castings on the Pacific Coast," by J. D. Fenstermacher, Columbia Steel Co., San Francisco.

Report of the Committee on Steel Foundry Standards, by W. A. Janssen, chairman, Canadian Steel Foundries, Ltd., Montreal, Que.

"The Electric Furnace in the Steel Foundry," by W. E. Moore, W. E. Moore & Co., Pittsburgh.

"The Advantages of the Basic Lining for Electric Furnaces," by F. J. Ryan, Electric Furnace Construction Co., Philadelphia, Pa.

"Effective Means of Improving the Quality of Foundry Sand Mixtures," by Henry B. Hanley, New London Ship & Engine Co., Froton, Conn.

"How Cost and Inspection Data are secured in the Foundry of the Naval Gun Factory," by Lieut. Walter S. Droxsey, U. S. Navy Yard, Washington, D. C.

Report of the A. F. A. Committee advisory to the United States Bureau of Standards, by Richard Moldenke, Marhung, N. J.

"Pyrometers and their Application to Core Ovens," by G. W. Keller, Brown Instrument Co., Philadelphia.

"Concrete Foundry Floors," by George Moyer, Textile Machine Works, Reading, Pa.

"A Pouring Device for Modern Foundries," by Mark P. Ohlsen, Brillion Iron Works, Brillion, Wis.

"Gas and Flame Warfare," shows in moving pictures.

---

## ELECTRIC STEEL MELTING FURNACES.

### The Booth-Hall Electric Furnace Was Described in Our April Issue, Page 128.

The Booth-Hall Company, manufacturers of electric furnaces, 2309-15 Archer Avenue, Chicago, Illinois, have placed in successful operation during the past few months, the following steel melting furnaces:

West Michigan Steel Foundry Co., Muskegon, Michigan, 3-ton basic castings for naval gun carriages.

Monroe Steel Castings Company, Monroe, Michigan, 1½-ton acid steel castings.

Queen City Foundry Company, Denver, Colorado, ¾-ton basic steel castings for Emergency Fleet Corps.

New England Steel Castings Company, East Longmeadow, Mass., 1½-ton acid steel castings.

In addition to these furnaces, there is also a ¾-ton acid lined furnace in operation at the plant of the Duriron Castings Company, Dayton, Ohio, used for experimental work in the manufacture of duriron, and a 1½-ton furnace at the Avery plant, Peoria, Illinois, basic, used for the manufacture of tractor castings.

# EDITORIAL

We owe our readers an explanation and apology in connection with our last issue. During the latter part of November and the whole of December we were in a completely disorganized state, owing to the removal of our printing and publishing offices from Montreal to St. Anne de Bellevue. The troubles incidental to such an upheaval were responsible for Iron and Steel not reaching our subscribers upon the proper date, and having explained the cause, it only remains for us to offer our apologies and regrets.

---

With this issue of Iron and Steel we complete the first twelve months of our career, and wish to avail ourselves of the opportunity to thank all those who have in anyway helped us along the difficult path of infancy. The experience gained during this period has pointed clearly in certain directions, and in these directions we intend to proceed in the future, in the hope that greater success may thereby be achieved. It has not been an easy matter to firmly plant the journal so that its future growth and usefulness may proceed uninterruptedly, the times were unsettled, and the iron and steel trade was too busy to trouble about new fields. Now, however, that we are returning to normal conditions, when manufacturers will be compelled to seek fresh outlets for their products, we are hoping for greater support from advertisers. We have received congatulatory letters from England, Australia, China, the United States, and many places in Canada, and feel that we are fast becoming recognised as the official publication of the iron industry in Canada. We recognise that this industry is only in its infancy, and have no fear in being optimistic as regards the future; and as this future development progresses we feel that the usefulness of Iron and Steel will progress in an equal ratio. If any of our readers can offer advice or assistance that will enable us to increase the value and power of the publication we shall be heartily glad to hear from them, and to give any suggestion the fullest possible consideration.

---

In Canada to-day we are having illustrations of golden opportunities being thrown away, of cases where quality is being sacrificed to quantity, and reputations being permanently injured. We have dwelt upon the folly of placing "round pegs in square holes" and now emphasize the contention that many of these "round pegs" do not know enough about the steel trade to keep them out of trouble. Where high grade steels are being made to a close chemical specification, it is essential that the conditions should be rigidly conformed to, but cases are repeatedly occurring where these conditions are violated, the material is not up to specification requirements, but still it is shipped out to customers. The result is the steel is unsatisfactory, sometimes quite useless for some specific purpose, and gets returned to the manufacturer with the result that Canadian products are given undesirable names, the trade seeks its metal elsewhere, and the firm pursuing this policy experiences heavy financial losses, besides losing whatever reputation it may have had. If manufacturers will only realize that the rule-of-thumb day is a thing of the past, that when steel is specified to contain certain amounts of various elements, this specification is drawn with the view of securing definite physical properties, or of making the metal amenable to certain thermal treatments. It is folly to try and substitute "off" metal, for by so doing one is only courting disaster, friction, and loss: far better take one's troubles inside one's own gates than risk shipping material upon which no confidence can be placed. It is another illustration of the "round peg," etc., for no man reasonably familiar with the composition, characteristics and duties of high grade steels would take such risks.

---

## CANADIAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

The following interesting and illuminative summary of the work of the Canadian Council for Scientific and Industrial Research appears in The Toronto Globe's annual financial survey, issued on January 2nd. Dr. A. B. Macallum, the administrative chairman of the Council, reviews the situation in Canada in regard to the application of science to industry as follows:—

"Re-construction and development" in Canada in the new era of international girding for supremacy in the arts of peace means to the Canadian Honorary Advisory Council for Scientific and Industrial Research much in so far as "development" is concerned, but little in regard to "re-construction." Re-construction postulates the building up again of what existed before; and up to the outbreak of war there was constructed in Canada no national organization for research work. The glowing path of Canada's opportunity for industrial development runs wide and far, but the Council's research path has to be blazed though a comparatively unexplored forest. It is almost entirely new ground to be covered.

Where Germany and, though perhaps in lesser degree, the United States had builded before the war great organizations for industrial research founded on wide-visioned realization of the commercial value and necessity of applying science to industry, in Canada, as in Great Britain, state encouragement and individual enterprise had, until the war started, been content in the main with a laissez-faire policy. Germany had her trained technologists and research workers by the thousands in every field of industry, and, through the organized application of science to industry, was winning her trade victories in every foreign mart.

In the United States, which early took a leaf from Germany's book, the great Universities like Harvard, Yale, Chicago, Columbia and Cornell had staffs and equipments in pure and applied science, which kept pace or almost kept pace, with the demand from great American industrial establishments for trained scientific investigators, chemists, electrical engineers, metallurgists, etc., to solve industrial research problems. The annual budget of the Massachusetts Institute of Technology, for instance, exceeded before the war, and still exceeds, the total of the annual expenditures of all the Faculties of Applied Science in Canada. There are some two thousand research laboratories in connection with large industrial concerns in the United States, and each of more than fifty individual firms expend annually sums ranging from $25,000 to $500,000 for research.

In Canada in a score of years less than twenty students have received the advanced (Ph.D.) degree in science from the University of Toronto and fewer still from McGill. Not two per cent of Canadian firms have research laboratories, and only about ten per cent have routine laboratories, chiefly for the testing of materials. If Canadian industries were to seek for a supply of trained technical men capable of applying the most advanced scientific knowledge to industrial processes sufficient to meet even their most ordinary needs, the number of adequately trained men available would not be sufficient to satisfy five per cent. of the demand.

That, briefly put, is the situation with regard to the needs in Canada for equipment and men for research work. That is the situation which has confronted the Research Council since its creation in December, 1916. And that has been, and is, the crux of all the problems of scientific and industrial research in Canada, handicapping the carrying out of the large research programme planned for the past year, and for the coming year, jeopardizing Canada's position in the international rivalry for export trade and demanding prompt remedy if the full measure of our opportunity is to be grasped. In resources of capital and materials, in all the natural advantages for industrial supremacy we are in an enviable position as compared with our trade competitors. But in regard to the vital question of scientific organization of our industrial processes of finding new uses and, hence new markets for the raw materials and the by-products of manufacture, and of keeping pace with the advances made in other countries through research, we have as yet hardly touched the fringe of opportunity.

Confronted with this situation and with a slowly awakening public and individual realization of its portent, the main task of the Council this past year has been, while carrying on the immediate needs of research work with the means at hand, to pave the way for meeting adequately the urgent needs of the future. The goal has been a supply of trained men for research work, adequate equipment and facilities for research, by all the public interests concerned. There is good rea- and the enlistment of industrial organizations in co-operative effort to solve common problems, the solution of which lies in the application of science to industry. The great forward step taken has been to promote the establishment of a Central Research Institute at Ottawa, combining the functions of the Bureau of Standards at Washington and of the Mellon Institute at Pittsburgh.

The proposal for such an Institute, submitted to the Government in November last, was the result of many months' careful investigation by the Council.

In view of the situation above outlined, the argument advanced in support of it is so obvious as to need no re-statement here. There has been a prompt and appreciative response to the proposal by the Government and by all the public interests concerned. There is good reason to believe that the Institute will be established without any unnecessary delay. It will involve an expenditure of $500,000 for a four-storey building, having initial provision for fifty laboratory rooms and with plans so drawn as to provide for expansion as the needs develop. The cost of the scientific equipment is estimated at $100,000, and the cost of maintenance, salaries, etc., at about $100,000 per annum for the first few years.

The establishment of the Institute is the necessary first step towards placing industrial research work in Canada upon an adequate and permanent basis and towards enabling the Dominion to keep abreast of similar progressive methods in the United States, Great Britain, Japan, France, Australia and our other trade competitors. It will, doubtless, be followed by the organization of trade guilds or associations for research in each branch of industry, formed to pool resources in solving common problems and to take advantage of the laboratory equipment and opportunity offered, under the Council's proposals, by the Government-maintained Institute.

A further necessary step will be the working out of the Council's plans for more adequate provision by the Universities for the training of qualified scientific workers. In the more generous investment of state funds for this purpose, starting, say, with Toronto, McGill, and L'Ecole Polytechnique in Montreal, lies the hope of securing for the ensuing years of the world's strenuous and pitiless trade warfare the nation's leaders in scientific and industrial research.

Apart from these crucial phases of the work and aims of the Research Council, space permits of only passing reference to some of the many research problems already undertaken.

As a result of the Council's initiative, Governmental action was taken in June last to secure federal co-operation with the governments of Saskatchewan and Manitoba in establishing a demonstration plant in the Souris coal areas of Southern Saskatchewan, to prove the commercial feasibility of carbonizing and briquetting the Western lignites for heating, in domestic furnaces. This year will see a plant established with an outlay of $400,000 and an annual output of 30,000 tons of coal equal to the Pennsylvania anthracite and marketed in Regina or Moosejaw at, at least, two dollars per ton less than the imported anthracite is now costing. The success of the initial plant, about which there can be little doubt, will lead eventually to the development of the immense and little realized latent lignite resources of Saskatchewan and Alberta, relieve for Ontario and Quebec the present coal famine through limited American supply and save to Canada the five or six

millions of dollars now annually going to the United States for coal for the prairie provinces.

A systematic study of the rate of reproduction and growth of Canadian forest trees of the commercial species has been undertaken through scientific survey of some eighty square miles of an old cut-over lumber district on the Petawawa Military Reserve. The data being secured will in the course of a few years give, for the first time, the essential definite information enabling the Dominion and Provincial Governments to inaugurate on a scientific and practical basis a scheme of re-forestation paralleling the best results obtained in the past in Europe. Our forest wealth, now in danger of exhaustion through reckless waste and disregard of adequate conservation systems, can only thus be preserved as a great and permanent national resource.

The tar fog research, initiated in 1917, has been continued with satisfactory practical results which will doubtless lead in the near future to the application to various plants in Canada of a new electrical process for the recovery of valuable by-products now lost in the destructive distillation of coal, wood, etc. The research on sound measurements and fog signalling conducted in 1917 by Dr. Louis King of McGill has made further progress this year and forecasts a new type of sirens for use in the St. Lawrence River and Gulf. Research work connected with the recovery of industrial alcohol from the enormous sulphite liquor waste of our Canadian pulp mills points to the installation of recovery plants and the production in Canada, at decreased cost to consumers, of the alcohol increasingly needed for industrial purposes and as a substitute for motor fuel.

There have been a score or more of other phases of industrial research initiated or continued during the year, each having a practical bearing on some branch of national production. More should and could be done, were trained men and money available. The Council's budget for the year has been under $100,000. In Great Britain, Parliament has recognized the need and the opportunity by creating a separate Department of Scientific and Industrial Research, and has voted one million dollars per annum for five years to be expended by the Research Council. In Canada we, too, are learning the obvious lesson taught by Germany and already adopted by British industry. The path has been blazed for replacing rule of thumb methods in Canada by scientific investigation.

## *TRADE WITH GERMANY.*

Trade with Germany was looked on somewhat askance even before the war, as it was recognized, in England for example, that German-made goods were dumped at prices that could not be met by English manufacturers, who paid a fair wage to workman. It was known in some cases that the sale price was less even than the cost of production in Germany where the rate of wages was lower than in England. The war has directed our attention to a number of things that had been partly overlooked, and England at war found herself painfully dependent on Germany for a number of important articles that had once been made in England, but were made there no longer, because German manufacturers, with the systematic aid of their Government, had undersold and driven out of business the English manufacturers. This condition had become possible because while the German Government conducted a carefuly thought out commercial warfare, the English Government, with its policy of free trade and *laissez-faire,* allowed this warfare to proceed under its nose without raising a finger to protect the English manufacturers.

During the war, trade with Germany has necessarily stopped, and we have been doing all within our power to render ourselves economically independent of German manufacturers. Now that the war is over we would like to continue this policy of no trade with Germany, but we cannot adhere to it rigidly, because, for example, Germany will have to pay an immense indemnity to the Allied Nations, and this can only be paid to a small extent in gold, as Germany has not enough gold for the purpose, but must be paid in raw supplies, such as potash salts, coal and ore, and in manufactured products. We have also the feeling that a permanent boycott, being an act of commercial warfare, is incompatible with the peace that we trust will ultimately prevail amongst *all* the nations of the earth.

It may be prudent, at the present time, to remind ourselves that, however much we may hope for universal peace in the future, Germans are not at present to be trusted, and that in making peace with Germany the utmost precautions must be taken to protect the commercial interests of the other nations against the unscrupulous methods of the German rulers.

During the war German merchants and engineers realized that after its termination, even with the German peace that they expected, German goods would be regarded with disfavour, and other countries would not trade willingly with Germany. A book entitled "The future of German Industrial Exports"[1] was written in 1915 by S. Herzog, a German engineer, to show German merchants how they could continue their industrial warfare, and as the book gives us a vivid and safeguarding insight into the methods to be employed by German merchants, it has been translated into English and put out for our warning by H. Hoover, V. Kellogg and F. C. Walcott, of the U.S. Food Administration. The book contains nearly 200 pages, and should be read by every Canadian business man. We print herewith the Introduction and a Summary (prepared by the translators) of each of the fourteen chapters:

[1] "The Future of German Industrial exports, by S. Herzog. Doubleday, Page and Co., 1918.

### *INTRODUCTION.*

"If there is anything to be gained by being honest, let us be honest; if it is necessary to deceive, let us deceive." Thus wrote Frederick the Great in the middle of the 18th Century—the man who laid the foundation of Pan-Germanism, which this world war was expected to achieve. Not content with dominion by force of arms, we find Germany plotting for commercial supremacy, with that insolent disregard of the rights of others, and that resort to deception that has characterized all her policies since Frederick the Great's reign.

The book of which this is a translation was written by an eminent German engineer and economist, and published in 1915, during the second year of the war. This book presents ingenious plans for driving home commercial victories at the expense of the trade of other countries. Like all of Germany's plans affecting other nations, the entire conception depends upon deceit and a superselfishness; not one word touching upon reciprocity, not one word in recognition of any international obligations.

It was obviously written exclusively for home consumption, and not intended for those outside the Iron

Circle. It should be a warning to us. We should study it with care, and keep our eyes and ears alert for other warnings of this sort, that in peace we may be prepared to meet this design of commercial rapine, this crushing of the industries of other countries.

For forty years the Germans have been plotting to realize their dreams of Pan-Germanism—eventual world conquest and dominion. For two generations they have been thinking in terms unknown or little understood by an innocent and unsuspecting world. The Prussian philosophy that might makes right, that the State is supreme, has completely possessed the ruling and upper classes of Germany, both military and commercial, until deception and fraud form the background of their most important international relations and undertakings. They have made Germany an inherently dishonest nation.

Their military plans were successfully concealed for years, and when their dreams of conquest did outcrop occasionally, there were few with an intimate enough knowledge of the complete premeditated and systematic degeneration of the German official character to read the handwriting on the wall.

Well organized and comprehensive espionage and insidious German propaganda have been at work for two generations to plan the success of German victories. In the early 90's of the last century, the German Volkschule was organized to teach the masses absolute subserviency to the upper and governing classes, whose education diverged from that of the lower classes at the age of seven or eight. The education of these two classes has been so divergent for thirty years that the effects are now clearly traceable in the younger men in the army, as contrasted with the members of the Landstrum army. The Landstrum men are much more humane, and have a restraining influence in the army. They have not been guilty of the excesses that are chargeable to the younger men. The younger men, schooled from infancy under the new system to obey orders in a machine-like way, under Prussian leadership, have become so ruthless, so cruel, that the entire civilized world looks aghast.

German rule means the breaking-down of all order, the exchange of personal liberty and national freedom for force, of right for might, of justice for the mailed fist.

The world should have been forewarned. Books were written, maps constructed, by well known German authorities for the enlightenment of the German people, and these books reached the outside world, but civilization, accustomed to the pursuits of peace, turned a deaf ear, and is now paying the penalty for refusing to see and hear.

Now another conception comes out of the heart of Germany, that threatens the commercial interests of unsuspecting nations—carefully thought out, with characteristic German thoroughness, opening advocating the breaking down of all business ethics, relying upon trickery and circumvention to gain their end. This promises to stop at nothing, from national dumping of goods to crush competition to false labels and disguise of the origin and the breaking of contracts that prove disadvantageous to the German.

Let the manufacturing and banking interests and the laboring and professional classes of all nations be warned in time to devise antidotes and counter attacks to the Machiavellian devices of a class gone mad with lust of conquest, deliberately plotting to fatten itself upon the life blood of other peoples even after the war. Let us consider in making peace what protection we can give to the commercial existence of the freed nations.

HERBERT HOOVER
VERNON KELLOGG
FREDERIC C. WALCOTT.

U.S. Food Administration,
Washington, D.C.

*Chapter I.—The Grand Strategy of the German Commercial Offensive.*

In this chapter the author blandly admits that after the war the entire world will regard the Germans with a hatred so bitter that even the commercial treaties they expect to dictate and write in blood will not prevail to open a cordial channel for their industrial products.

Notwithstanding this the Germans still plan and expect to dominate the trade of the world. For trade to them is simply another form of combat to the death. And for this they are organized and prepared.

Their export trade in its maximum proportions is to be forced down the throats of America and the Allies. The invincible weapon is to be the "unsurpassable goods" produced by "indispensable industries,"—monopolies conducted under military system, rigidly confined to German soil, and guarded by an impenetrable veil of secrecy.

*Chapter II.—Forging the Thunderbolt.*

To be invincible, "the unsurpassable goods," by the lack of which Germany is to strangle us into swallowing the whole output of their factories, must be independent of nature's materials found in Alabama, New Mexico, Chile, and other "prejudiced" countries. Well, they have this planned also, as this chapter shows. Mobilized and drilled, the scientists of the Empire will be incorporated into the export army and under discipline are to produce Prussian substitutes for all such necessary raw materials.

The Germans propose to take drastic action to meet what they call the menace of great stores of surplus capital which America has accumulated through what they term the regardless and barbarous manufacture of murderous war supplies. One of the principal manoeuvres will be the adoption and improvement of the American system of standardizing manufactures.

*Chapter III.—The Camouflage of Commerce.*

The Germans, as the following chapter shows, expect impenetrable disguise to be a leading feature in renewing their oversea business. Their salesmen will be trained to correctly imitate the aspect, intonation, idiom, and "provincialities" of their customers, and cleverly to copy their business methods and their style of making packages and shipments.

Allied countries that refrain from interference (although "hypercritical"), Germany intends to reward—with her matchless goods. Those that refuse to be duped are to meet "relentless retribution." A general staff having determined by means of infallible "defence statistics" that America or some other culprit is neglecting to take its allotted German exports, will order the "indispensable industries," subsidized by "economic compensations" to boycott the victim, and it will seal the command with a "corrective embargo."

*Chapter IV.—Indispensable Industries.*

The German sets forth in Chapter IV. by what process he proposes to blackmail the world with his "Indispensable Industries." For this purpose he intends to maintain exclusive control of them by a rigid and de-

spotic "state sovereignty" expressly adopted to limit "the freedom of the individual, science, and property."

These strategic industries will embrace such natural monopolies as potash, such results of the German system as dyestuffs and carbolic acid, chemicals, steels of special value and gelatine, which they believe inimitable. Beyond these, such products as they have or can render irreplaceable, technically superior and infinitely cheaper, of a nature to cause great economic suffering by their lack, and which can be made exclusively of materials obtainable always in Germany, will be selected to constitute the "Prussian Guard" of their industrial invasion, and to be put under the invigorating husbandry of the Military Regime.

*Chapter V.—The Golden Guarantee and Discipline of Labour.*

In order to strangle any possible competition by the United States and her Allies in the production of those "unsurpassable goods" with which she is to throttle us eventually, the Germans are to incorporate all their export industries into a "union' under military control. And this union will levy contributions from all its members for a "guarantee fund." The Guarantee Fund will "insure" that these strategic goods undersell all possible competitors. For while the State provides the constant supply of raw materials, below cost, the fund flows in to reimburse the miner, and finance the hiatus caused by the "pitiless embargo" and maintain the surplus stocks for future offensive manoeuvres. Besides ,the indispensable industries will never be hampered, as ours are, by the demands of labour. Strikes, the writer here says, are "unthinkable' in this campaign, and will be met by swift and terrible retribution.

*Chapter VI.—The Chinese Wall of Secrecy.*

Obsessed by the fear that their invaluable monopolies, the "shock troops" of their intended commercial conquests, will be imitated or transplanted to America or France or England, the Germans decree that no alien capital shall have any interest in any of them. To keep them at maximum efficiency they proposed to replace all machinery to keep pace with even the minutest improvement; to compel every scientist and inventor in the Empire to reveal his discoveries instantly to the monopolies, and to guard all their plants and processes with a cordon of bayonets. They are going to bolster these monstrosities of commerce with what they plainly call "special privileges"—rebates, tax remissions, premiums, long working hours, priority orders. And every employee, from president to water-boy, is to be enlisted for life—the better to create an "hereditary personnel" and maintain the pall of secrecy.

*Chapter VII.—Diplomacy the Advance Guard of the Export War.*

To maintain exclusive and overwhelming advantages for German commerce throughout the world, the German Diplomatic Advance Guard of the Commercial Diplomatic corps will operate as an Advance Guard of the Commercial Invasion, working in secret unison with every agency—to-wit, every German — in Allied lands. The "Defence Statistics," trade conditions, business methods and markets, and all actions hostile to Kultur will thus instantly be marshalled and reported. And the Kaiser presumes that by dint of offering to trade rebate for rebate, subsidy for subsidy, and private advantage for German toleration, some nations can be translated into the Prussian influence and will open their doors with privy welcome to German goods. Temptation, in the shape of secret concessions, and incentive, in the shape of murderous threats, are to be skilfully manipulated by the Ambassadors from Berlin, constituting the weapons with which the Allies in succession are to be dragged into the spider's web.

*Chapter VIII.—A Feudal System of Commerce.*

In order to accomplish their programme, the commercial war lords of Essen and Hamburg agree that absolute and dictatorial power shall remain in the German "State." It is to retain the "Divine Right" by which it can forthwith commandeer those minerals that are the life blood of industry; to sentence labouring men for life to any pursuit at any wages, and hedge them around with jailers; to draft experts and captains of industry upon service determined by the General Staff; to decree tariffs, embargoes, freight rates, rebates, premiums and subsidies at will; to levy "contributions" upon all business and all workmen alike, disposing thereof as it chooses, and to direct the personal actions, aspirations, endeavours, and rewards of all men of scientific, technical, or financial capacity. Not only personal liberty, but the immortal spark of genius is to be chained to the Imperial chariot wheels.

*Chapter IX.—Organization of the German Export Army.*

Just as every suitable human being in the empire was drafted into the army, so every plant in the Kingdom is to be conscripted into the German Industrial Army for the export war. Each industry will constitute an Army Corps, divided into five divisions—scientific, industrial, mercantile, commercial and financial. Presiding over each division will be a generalissimo. These generalissimos, together with a controlling number of state functionaries, will constitute the five great Boards of Strategy, whose heads in turn will be the Great General Staff, the fountain head and final dictator of the campaign.

The Scientific Division will draft into service all inventors and conduct in carefully formulated detail the production and application of those inventions and discoveries required by the Industrial Division, which in turn will marshal them where most needed, and act as an immense clearing house and information bureau for all technical improvements.

*Chapter X.—The Export Army in Action.*

The Field Marshals who are to execute the active manoeuvres of the coming trade war, will operate from the commercial Divisional Headquarters. Theirs the duty to snap out the orders, to hoard up the potash, hold up the shipping, slap on the premium and distribute the largess which will gather in their war chest. Theirs the privilege of enrolling the secret army that will permeate every rolling mill and drug store in Christendom, and of dictating the thunder of diplomat and war lord when their schemes begin to fail. To the last comma their duties are defined—how they will outflank the Yankees through neutral territory, eliminate friction by not tolerating it, establish themselves as an inevitable collection agency for German merchants, and straddle the world as a court of last resort passing upon all trade disputes under the sun.

*Chapter XI.—A Study in Scarlet. The Proposed Treaties.*

Preceding the Export War, the German plan contemplates laying a monumental foundation for the siege guns of commerce with the peace treaties. Blandly stating that they will be dictated in Potsdam and written in blood, they have tabulated their "minimum demands." These will impose upon the United States and all creation the conditions that the Prussians may select their own properties in our country and operate them under Imperial jurisdiction; that their officials be sta-

tioned in Allied territory to punish anyone refusing to buy their goods; that we give bonds guaranteeing their enforced investments and accounts, and that we purchase from them exactly the amount of all their exports which they shall command. And they add that they will "consider whether it is not well to demand exclusive favouritism of Germany in this point or that, or in all"!

*Chapter XII.—The Denationalization Dodge. An Antidote to Hatred.*

To neutralize hostility and allay the suspicions of allied customers, the advance guard of the German invasion will offer for sale only "Denationalized goods." They will appear to be "anonymous"—cosmopolitan. To maintain this disguise, the Teutons decree that everyone else shall keep their goods also free from mark or sign. Advertisements and shipments of these products incognito will appear to come from neutral countries, and will be spirited into our homes and our stores by clever actors sedulously made up to resemble our harmless neighbours. Even their correspondence, mineographed in Berlin in Bostonian English will bear a neutral post mark and an impartial signature.

*Chapter XIII.—The Hereditary Workmen of Combined Industries.*

The German confidence in the outcome of his ruthless cut-throat battle for the markets of the world is ultimately based upon a complacent assurance of their superior genius. They propose to reinforce this with a really formidable weapon—high speed and painstaking efficiency. All small traders and manufacturers are to be eliminated without pity. Production is to be mobilized in great Trusts and strictly standardized. The labour is to be permanent and hereditary. No man in Germany will be allowed to conduct a plant unless he adopts the military regulations defining efficiency. And incompetence and failure will be marked down for the wrath and annihilation of the State. Efficiency is not only to be taught and studied, but commanded.

*Chapter XIV.—The Curb on Capital.*

Assuming the role of the supply train, the bankers and capitalists of Germany will henceforth supply their golden ammunition to German commercial units only. The High Command in Potsdam, perceiving that the Entente has no more moral regard for property than to seize German accounts, has decreed that henceforth no German money shall be invested except in German industries, and in those outposts of the advancing German export trade which directly profit in the commercial war. And this plan further contemplates two other rigid limitations upon all banking. That no allied capital shall ever find its way into the "Indispensable Industries" of Germany and that for a German banker to refuse a loan to one of these "offensive units," is strictly "verboten."

## CANADIAN MINING INSTITUTE.

When the results of the ballot for President of the Canadian Mining Institute are announced we hope to find the name of Mr. D. H. McDougall, and to know that he will occupy the chair for the ensuing twelve months. From pit-boy to president of a Mining Institute, with the Institute reaping all the benefit of intermediate experience, is an achievement to be proud of, and it will be cause for sincere regret if anything prevents such an accomplishment from being recorded. Mr. McDougall is only a young man, but has succeeded in building up an enviable reputation with whatever duties he has had to perform. Starting in a Cape Breton coal mine as a boy, his every action showed ambitious determination, and he successively devoted his attention to mechanical work, surveying and railway engineering, iron and coal mining, and finally to the control of steel production on a large scale. Mr. McDougall's experience in Canadian mining matters, his knowledge of men and affairs, and his undoubted success as an organizer render him eminently suitable for President of the Canadian Mining Institute, ad we reiterate our hope that nothing will occur to prevent his election to the position.

---

In another portion of this issue we publish a summary of the work done by the Canadian Council for Scientific and Industrial Research. The writer emphasizes the fact that this research path has to be blazed through almost unexplored territory, which calls for trained technologists and scientists in every field of industry. This work can only be handled in a successful manner and yield the maximum result after its absolute necessity has been recognized. In the United States there are some two thousand research laboratories conducted by large industrial concerns, and each of more than fifty individual firms expend annually sums ranging from $25,000 to $500,000 for research. Innumerable problems bearing upon industrial progress are awaiting solution in Canada, such problems, if a concerted scheme of attack was organized, would fail to find an available supply of adequately trained men. According to the inexorable law of demand and supply, it is safe to assume that, had manufacturers in the past recognized the potential value of science as applied to their manufacturing operations, the incentive would have existed and men would have been found willing to devote themselves to research work. In many plants today the chemist and metallurgist is looked upon as a sort of necessary evil, his work receives but scant consideration, and quite frequently his advice is entirely ignored. If Canada is to develop to the utmost along industrial lines: if her natural resources are to receive maximum exploitation: then will it be necessary for her to create an army of trained men qualified to undertake all classes of research work. The McGill University is doing a lot to foster this spirit of knowledge, and has arranged for an extension course of twenty-six lectures on Industrial Chemistry. Many well known men are giving their services as lecturers, and it is to be hoped the movement will receive the cordial co-operation and support of those to whom such addresses should prove invaluable.

---

Chromium is an indispensable constituent in modern high-speed steel, and makes a by no means despicable high-speed "steel" when used alone. Finally it is the essential constituent of those steels which neither rust nor tarnish, and its ferro alloys are comparatively abundant and cheap.

## *BOOKS ON METALLURGY: "DE RE METALLICA"*

(From *Canadian Bookman.*)

Metallurgy is one of the oldest of the arts; a knowledge of its mysteries was highly prized in olden days, and its practice has ben shrouded in secrecy even in modern times. The manager of many a metallurgical works would refuse admittance to visitors for fear of disclosing some secret on which the technical and financial success of the industry was supposed to depend. Under these conditions metallurgical literature was limited, although important works were written, and advances were slow. In recent years a more liberal spirit has been observed; nowadays, it is generally recognized that a plant from which visitors are excluded is probably behind the times, and as a result of the freer exchange of knowledge and ideas the art and science of metallurgy are making rapid progress.

Under these conditions metallurgical literature is world-wide in scope and distribution. Processes that are limited in use to a particular country or district are becoming fewer and of less importance, and metallurgists in any country can keep in touch with the advances in the science and practice of their art in all parts of the habitable world. It will be clear, then, that there is scarcely such a thing as English metallurgy, Scotch metallurgy, Canadian metallurgy; although we sometimes speak of American metallurgy, having in mind the fact that on this continent smelting methods have been undertaken on a larger scale and with a freedom from precedent that was unknown in the past in European countries. Books on metallurgy, when written in English, are usually published in London or New York, and authors who may happen to be located in Canada have their works published in one of these places. Technical books of this kind involve much work in writing and considerable expense in printing and publishing, the reading public in Canada is small, and, in consequence, Canadian publishers are unable to handle such books. A work of any importance, on a subject of such wide-spread interest, must be brought out by publishers having world-wide affiliations, and the only limiting circumstance is the survival of different languages, which still makes it necessary to translate English books into French, Spanish, German and other languages, while metallurgical works in those tongues are translated into English. We may also regret the medieval custom of writing in Latin so that all scholars would understand.

Although it will be impossible to observe a chronological order in dealing with works on metallurgy, it seems fitting to place in this introductory article a notice of the first book of any importance dealing with the subject of metallurgy. "De Re Metallica"—written in Latin by Georgius Agricola early in the sixteenth century and published in 1556—has at last been worthily translated into English by Herbert Clark Hoover and Lou Henry Hoover, and was published in a de luxe edition in 1912. The noble part which Mr. Hoover has played in the present war adds interest to the labour of love which occupied him and his wife for about five years.

Georgius Agricola (Georg Bauer) was born at Glauchau in Saxony in 1494, about the beginning of the revival of learning, and his writings, although to us they seem archaic and somewhat obscure, mark a great advance when compared with contemporary writings on the subject. One of the features of "De Re Metallica" is the large number of wood-cuts, which have been reproduced, faithfully, in the translation. The following extracts will indicate the character of the work, which covers the subject of mining, ore-dressing, assaying, smelting and refining of metals as known at that time.

The preface is addressed: "To the most illustrious and most mighty dukes of Saxony, Langraves of Thuringia, Margraves of Meissen, Imperial Overlords of Saxony, Burgraves of Altenberg and Magdeburg, Counts of Brena, Lords of Pleissngrland, to Maurice, Grand Marshall and Elector of the Holy Roman Empire and to his brother Augustus.

In it he states: Without doubt, none of the arts is older than agriculture, but that of the metals is not less ancient; in fact they are at least equal and coeval, for no mortal man ever tilled a field without implements. In truth, in all the works of agriculture, as in the other arts, implements are used which are made from metals, or which could not be made without the use of metals; for this reason the metals are of the greatest necessity to man.

With reference to the alchemists he writes: These masters teach their disciples that the base metals, when smelted, are broken up; also they teach the methods by which they reduce them to primary parts and remove whatever is superfluous in them, and by supplying what is wanted make out of them precious metals—that is, gold and silver—all of which they carry out in a crucible. Whether they can do these things or not I cannot decide; but, seeing that so many writers assure us with all earnestness that they have reached that goal for which they aimed, it would seem that faith might be placed in them; yet also seeing that we do not read of any of them ever having become rich by this art, . . . . . . I should say the matter is dubious.

In Book I. he writes: Many persons hold the opinion that the metal industries are fortuitous and that the occupation is one of sordid toil, and altogether a kind of business requiring not so much skill as labour. But as for myself, when I reflect carefully upon its special points one by one, it appears to be far otherwise."

He also argues against the prevailing belief that it is wicked to have or obtain metals: "In the first place then, those who speak ill of the metals and refuse to make use of them, do not see that they accuse and condemn as wicked the Creator Himself, when they assert that He fashioned some things vainly and without good cause, and thus they regard Him as the Author of evils, which opinion is certainly not worthy of pious and sensible men. In the next place, the earth does not conceal metals in her depths because she does not wish that men should dig them out, but because provident and sagacious Nature has appointed for each thing its place."

With respect to the divining rod he writes:—"There are many great contentions between miners concerning the forked twig, for some say that it is of the greatest use in discovering veins, and others deny it. Some of those who manipulate and use the twig, first cut a fork from a hazel bush with a knife, for this bush they consider more efficacious than any other for revealing the veins, especially if the hazel bush grows above a vein. . . . Since this matter remains in dispute and causes much dissention amongst miners, I consider it ought to be examined in its own merits. . . . The Ancients, by means of the divining rod, not only procured those things necessary for a livelihood or for luxury, but they were also able to alter the forms of things by it; as when the magicians changed the rods of the Egyptians into serpents, as the writings of the Hebrews relate; and as in Homer, Minerva with a divining rod turned the

aged Ulysses suddenly into a youth, and then restored him back again to old age. . . Therefore it seems that the divining rod passed to the mines from its impure origin with the magicians. Then when good men shrank with horror from the incantations and rejected them, the twig was retained by the unsophisticated common miners, and in searching for new veins some traces of these ancient usages remain."

Although doubtful about the divining rod, Agricola believed in subterranean demons:—"In some of our mines, however, though in very few, there are other pernicious pests. These are demons of ferocious aspect, about which I have spoken in my book 'De Animantibus Subterraneis.' Demons of this kind are expelled and put to flight by prayer and fasting. Some of these evils, as well as certain other things, are the reason why pits are occasionally abandoned. But the first and principal cause is that they do not yield metal."

His instructions to assayers read correctly at the present time:—"It is necessary that the assayer who is testing ore or metals should be prepared and instructed in all things necessary in assaying, and that he should close the doors of the room in which the assay furnace stands, lest anyone coming at an inopportune moment might disturb his thoughts when they are intent on the work. It is also necessary for him to place his balances in a case, so that when he weighs the little buttons of metal the scales may not be agitated by a draught of air."

I may add in full his instructions for assaying an ore of gold, to show how closely they resemble our modern methods:—"Mix one part of this ore, when it has been roasted, crushed and washed, with three parts of some powder compound which melts ore, and six parts of lead. Put the charge into the triangular crucible, place it in the iron hoop to which the double bellows reaches, and heat first in a slow fire, and afterward gradually in a fiercer fire, till it melts and flows like water. If the ore does not melt, add to it a little more of these fluxes, mixed with an equal portion of yellow litharge, and stir it with a hot iron rod until it all melts. Then take the crucible out of the hoop, shake off the button when it has cooled, and when it has been cleansed, melt first in the scorifier and afterward in the cupel. Finally, rub the gold which has settled in the bottom of the cupel, after it has been taken out and cooled, on the touchstone, in order to find out what proportion of silver it contains."

Book IX. on the smelting of ores begins as follows: "Since I have written on the varied work of preparing the ores, I will now write of the various methods of smelting them. Although those who burn, roast and calcine the ore, take from it something which is mixed or combined with the metals; and those who crush it with stamps take away much; and those who wash, screen and sort it, take away still more; yet they cannot remove all which conceals the metal from the eye and renders it crude and unformed. Wherefore smelting is necessary, for by this means earths, solidified juices and stones are separated from metals so that they obtain their proper color and become pure, and may be of great use to mankind in many ways. When the ore is melted, those things which were mixed with the metal before it was melted are driven forth, because the metal is perfected by fire in this manner."

The following is a description of the smelting of a complex ore containing gold, silver, copper and lead:—"After a quarter of an hour, when the lead which the assistant has placed in the forehearth is melted, the master opens the tap-hole of the furnace with a tapping bar. . . . The slag first flows from the furnace into the forehearth, and in it are stones mixed with metal or with the metal adhering to them partly altered, the slag also containing earth and solidified juices. After this the material from the melted pyrites flows out, and then the molten lead contained in the forehearth absorbs the gold and silver. When that which has run out has stood for some time in the forehearth, in order to be able to separate one from the other, the master first either skims off slags with the hooked bar or else lifts them off with an iron fork; the slags, as they are very light, float on the top. He next draws off the cakes of melted pyrites, which as they are medium weight hold the middle place; he leaves in the forehearth the alloy of gold or silver with the lead, for these being the heaviest, sink to the bottom."

With regard to iron smelting the author writes:—"Very good iron ore is smelted in a furnace almost like the cupellation furnace. The hearth is three and a half feet high, and five feet long and wide; in the centre of it is a crucible a foot deep and one and a half feet wide, but it may be deeper or shallower, wider or narrower, according to whether more or less ore is to be made into iron. A certain quantity of iron ore is given to the master, out of which he may smelt much or little iron. He being about to expend his skill and labour on this matter, first throws charcoal into the crucible, and sprinkles over it an iron shovel-ful of crushed iron ore mixed with unslaked lime. Then he repeatedly throws on charcoal and sprinkles it with ore, and continues until he has slowly built up a heap; it melts when the charcoal has been kindled and the fire violently stimulated by the blast of the bellows, which are skilfully fixed in a pipe. there are holes through which he may see and breathe."

This work, as translated by Hoover, contains in addition to the translation, an enormous number of explanatory foot notes by the translator; it contains more than 600 pages, 9 inches by 13 inches, and is bound in vellum. It was published for the Translators by the Mining Magazine, London.

ALFRED STANSFIELD.

McGill University,
November, 1918.

---

## USE OF CRIPPLES IN INDUSTRY.

By JAMES P. MUNROE, Vice-Chairman, Federal Board for Vocational Education, Washington, D.C.

(Reprint of a paper to be presented at the meeting of the American Institute of Mining Engineers in New York, February, 1919.)

Appalling as has been the loss of life in the last 51 months, there is one slight compensation: no longer will there be in the world a cripple, in the old meaning of the term. Men handicapped by wounds or disease, there will be, unfortunately, and in numbers beyond what the world has known since the wars of Napoleon; but neither they nor the industries from which they were called off to war will be "crippled" in the sense in which both would have been had mankind not learned the lesson of conservation and come to understand that the most important field for such conservation is not in the forests and the mines but among men and women.

From the beginning of the Great War, France, Great

Britain, Belgium, and most of the other Allies have studied the problem of restoring the soldiers and sailors injured through war to physical and economic efficiency; and from their experiences, especially from that of Canada, the United States has learned much. Consequently, our task of preparing for the return of our disabled men has been easier and, in some ways, more comprehensive than theirs. Complex as are the details of the machinery which the United States has set in motion to take care of the men injured by wounds or disease, the plan itself is simple. Taught by European experience, the Surgeon-General of the Army and the Bureau of Medicine and Surgery of the Navy have provided, on both sides of the Atlantic, every known surgical and medical facility for restoring the injured or diseased man to a physical condition as nearly normal as possible. While in the hospital in France or England, on the transport coming to America, and in the hospital here, the disabled man is incited in every way to believe in his future efficiency, to want to be a normal worker, to desire to retake his place in that society of workers from which he went, temporarily, to do the greater work of preserving civilization. Furthermore since purposeful occupation is now regarded as an essential form of treatment with most men in the hospital, especially in the convalescing stage, many of these men will have been actually started on the road to earning before they are discharged from the army surgeon's care.

As soon as it is decided that a patient is ready for discharge from the hospital—and, now that hostilities have ceased, from the Army and Navy itself—his case is certified to two bodies: the War Risk Insurance Bureau, which is to determine the amount, if any, of his compensation under the War Risk Act, and the Federal Board for Vocational Education, which stands ready to help him to get back into employment and, if he needs it, to secure a preliminary training that will enable him to make the most of himself, under the conditions of his handicap, in that employment.

The Federal Board has no authority over the man thus placed under its care; it is for him to decide whether or not he wishes to avail himself of the help that the Federal Government thus offers. But if he chooses to use the facilities tendered by the Board, there is almost no limit, within reason, to what that organization may undertake for him. Its simplest task is, of course, to assist him in getting back into his old employment; but if he has ambition to get something better or if it is apparent that, by training, he can be more efficient in what he did before, the Board has authority to give him, at Government expense, as much education as, in its opinion, it is worth while for him to have. Every endeavor will be made to train the disabled man so that not only may his handicap be overcome, but that he may be carried, through an education perhaps denied to him before going to war, to a plane of efficiency that, without this opportunity, he could not have reached. Experience in other countries has shown that, in many instances, the disabled man is, after training and despite his handicap, a much more effective man than he was before the war.

While the disabled soldier or sailor is under no compulsion to take training, there are certain incentives, besides that of ambition, which the Government puts before him. If he desires to be trained and the Federal Board believes that he will profit by it, he is so certified to the War Risk Insurance Bureau, which at once classes him as entitled, during training, to the compensation provided for cases of temporary total disability, and, during the period of training, makes specified allotments to his dependents, should he have them. If he does not pursue the course of training with due diligence, these extra compensations, on representation of the Federal Board, may be withdrawn.

Training will be carried on in public and private schools and colleges and in industrial plants under contracts made between them and the Federal Board. The period of training will be determined to meet the needs of each case, but in every instance the disabled man is to be regarded as a special problem and the instructional work given him will be fitted to his needs. It will be attempted, as far as possible, to obtain for him a position in advance of his being ready for it, so that his training may be focused upon a specific goal. Should it prove, after employment, that his choice was unwise, the Board has authority to give him further training along that, or some new line. Moreover, after placement, whether with or without training, the Board will keep closely in touch with the man until it feels certain that he is firmly established in his industrial, commercial or professional life.

To carry out the duty placed on it by Congress, the Federal Board has established, or is establishing, headquarters, in Washington and fourteen of the other leading cities of the country. As far as possible, the disabled man will be placed and trained in his own State and locality. Every effort will be made to put him into occupations that are growing, and so to train him that, when hard times come and the fervor of patriotism has passed, he will be retained, not because he is a former soldier or sailor, but because he is a workman necessary to the work. Care will be taken, moreover, that he is not exploited and that he is not used as an instrument to disturb the labor situation. The complicated problems that might arise, in many States, in connection with employer's liability laws will not come up, since the number of disabled men is happily much less than it seemed probable that the United States would have.

The comparative smallness of the problem in the case of men injured in the pursuit of war serves but to emphasize the greatness of the number of men and women injured every year in the pursuit of the activities of peace. By the hundreds of thousands they meet with accident and injury in every degree and form. Heretofore, most of these injured persons have, so far as their economic usefulness is concerned, been thrown on the scrap-heap of society, with anguish to themselves and their relatives, with incalculable loss to the community. The war has taught us that this waste is needless and wrong; and if a bill now before the Congress becomes law, the Federal Board will be charged with providing, in co-operation with the several States, facilities for training and retraining these victims of industry along the same geneal lines as those followed with the victims of war. The task will be far greater than in the case of the disabled soldiers and sailors; it will not be, as with them, a comparatively temporary responsibility. It will go on forever, as long as there are machines, carelessness, and the inevitable lapses in human minds and senses, and the problem will have many complications that do not arise with those disabled in war. But the effects of rehabilitation in the field of industry will be as much broader in their final results as the scope of the permanent and normal arts of peace is greater than that of the temporary and abnormal art of war.

# Canadian Car & Foundry Company and Shipbuilding

In one of our earlier issues we published an illustrated article dealing with the shipbuilding activities of Messrs. Canadian Vickers & Co., and in this number we present a similar article concerning the Fort William plant of the Canadian Car and Foundry Co. The venture was an initial excursion into a new sphere, and was undertaken in the face of somewhat unusual conditions. In February, 1917, the contract was signed for the building of twelve steel mine sweeping vessels for the French Government, and the last was delivered early in November, a good illustration of the adaptability of Canadian manufacturing firms. The main shops at Fort William are situated approximately 1,000 feet from the Kaministiquia River and about forty feet above water level. In considering the question of executing this contract it had to be decided whether it would be more advantageous to build the ships near the car shops or adjacent to the water's edge. In case of the former idea being adopted, it would become necessary to transport the vessels from their berths to the water. If the decision went the other way it meant that the berths would be situated away from the main plant, with its power, stores and general conveniences. It was finally decided to locate the ship yard adjacent to the shops and to adopt mechanical means for transporting the vessels, as completed, to the water. This is the first time, within our knowledge, that it has been found advantageous to adopt such a course, and the mechanical arrangements for achieving this scheme are illustrated in the accompanying plates. Six building berths were arranged in a specially designed steel and concrete building, placed adjacent to the main car shops; and each of these was provided with travelling crane facilities so arranged as to conveniently handle the steel plates and structural sections as and where they were required during the construction of the vessels. The general dimensions of these trawlers were:—

Length overall, 143 feet.

Length between perpendiculars, 135 feet.

Breadth moulded 22 ft. 6 inches.

Depth moulded to main deck, 13 ft. 3 inches.

Depth moulded to quarter deck, 14 ft. 3 inches.

Displacement loaded, 630 tons.

Free board Lloyds, 15 inches.

They are of the single screw, steel steam trawler type, and were built to the full requirements of Lloyds Register Class 100 A1 steam trawlers. Single deck, with raised quarter and forecastle decks, and steel deck house. The top of the boiler house and winch casing form the navigating bridge, on which is placed a steel structure containing the captain's room and wheelhouse. On top of the deck house aft there is an enclosure for the wireless telegraph installation, and alongside of the lifeboats platforms have been provided. Two masts of Oregon fir are fitted, the foremost stepped in a cast housing on the main deck, and the main is housed by the deck house aft. Steam steering engines are installed in the upper engine rooms, and included in the deck machinery equipment are a double cylinder two drum trawl winch with reversing engines, a double cylinder single drum hoister with non-reversing engines, and a steam windlass. After the hulls were completed, see Plate I.

They were supported upon two cradles which were in turn carried upon four specially constructed trucks.

The hulls were then drawn from the berths, by means of a cable and locomotive, and on to a transfer table, as illustrated by Plate IV.

(See Plate III.)

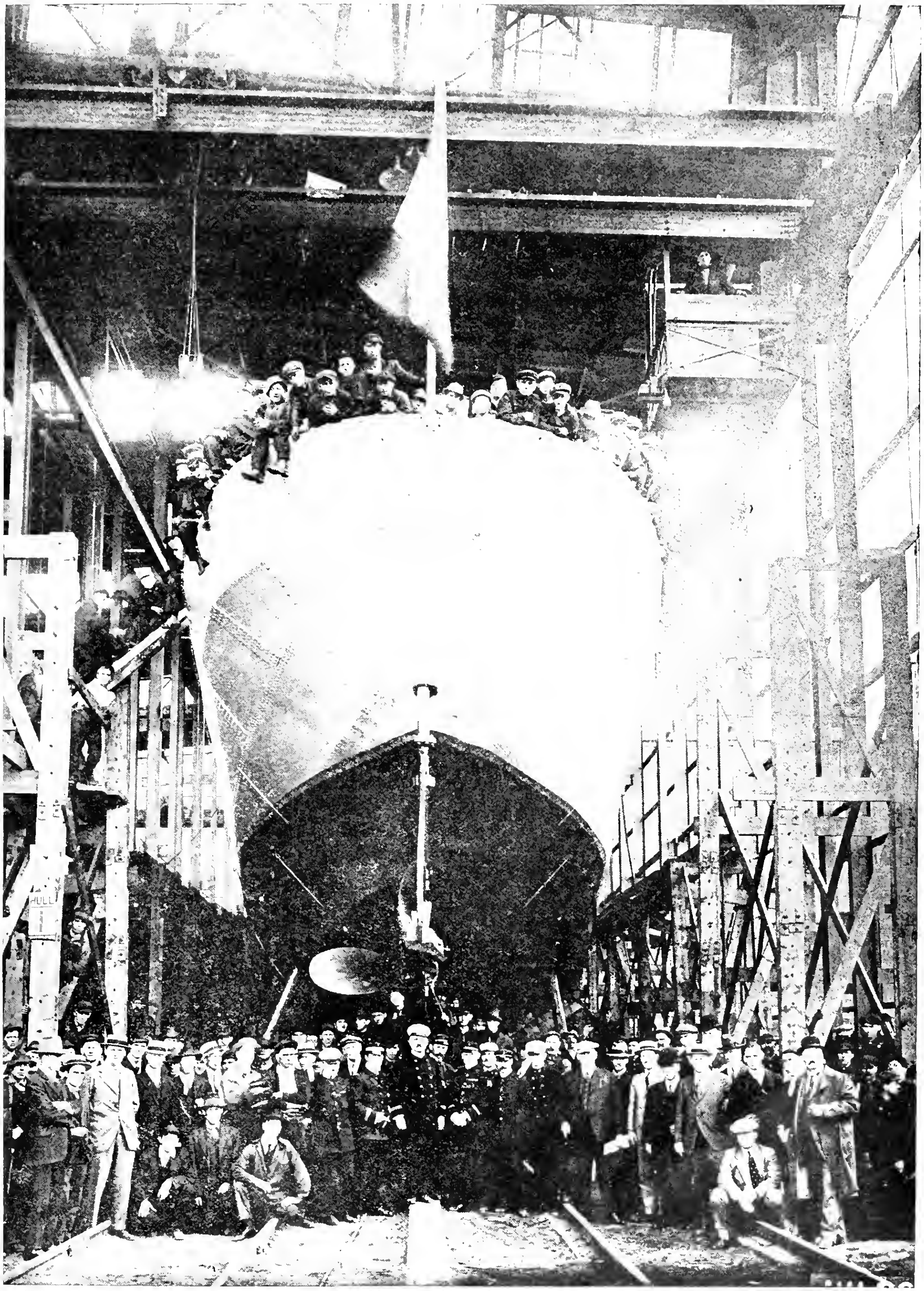
This allowed the boat to be moved in either direction to line it up with the single set of tracks laid from this transfer table to the river. The locomotive and cable were still utilized to move the ship further towards the river until Montreal Street, the Grand Trunk Pacific Railway, and the Street Railway tracks had been crossed. Immediately after crossing these tracks the incline to the water, about an 8 per cent grade, commences. At this point another locomotive was attached by a cable and the boat from there on descends to the river by its own weight. It was held in check by the cable which was fastened to the bow and connected with the locomotive, and was controlled in its downward travel by the air brakes on the locomotive. Plates V. and VI. respectively show the engine with cable connection for controlling a boat as it moved down the slip, and also the cable connected for the same purpose.

The bank approaching the river was cut away to take care of the 40 feet difference in level and to form a slip into the river, and the tracks were laid so as to permit the launching trucks to enter the water. By this means vessel and trucks both took the water and when the latter was sufficiently deep the boat floated off and the trucks were withdrawn for future service.

It was necessary to dredge out a launching basin and as this was not completed where the Navarin was she was launched inside the temporary cofferdam.

(See Plate VII.)

The last plate, No. VIII, shows the "Navarin" ready for delivery. After completion these trawlers were all inspected by representatives of the French Commission, and after passing speed, coal consumption, and other trials were finally accepted. From an economic point we cannot express an opinion, but the scheme adopted at this plant was certainly an innovation. As regards future undertakings we shall be surprised if we do not hear of many more boats being built at the Fort William plant of the Canadian Car and Foundry Company.



Navarin in building birth—stern view. French officials in foreground.
**PLATE I.**

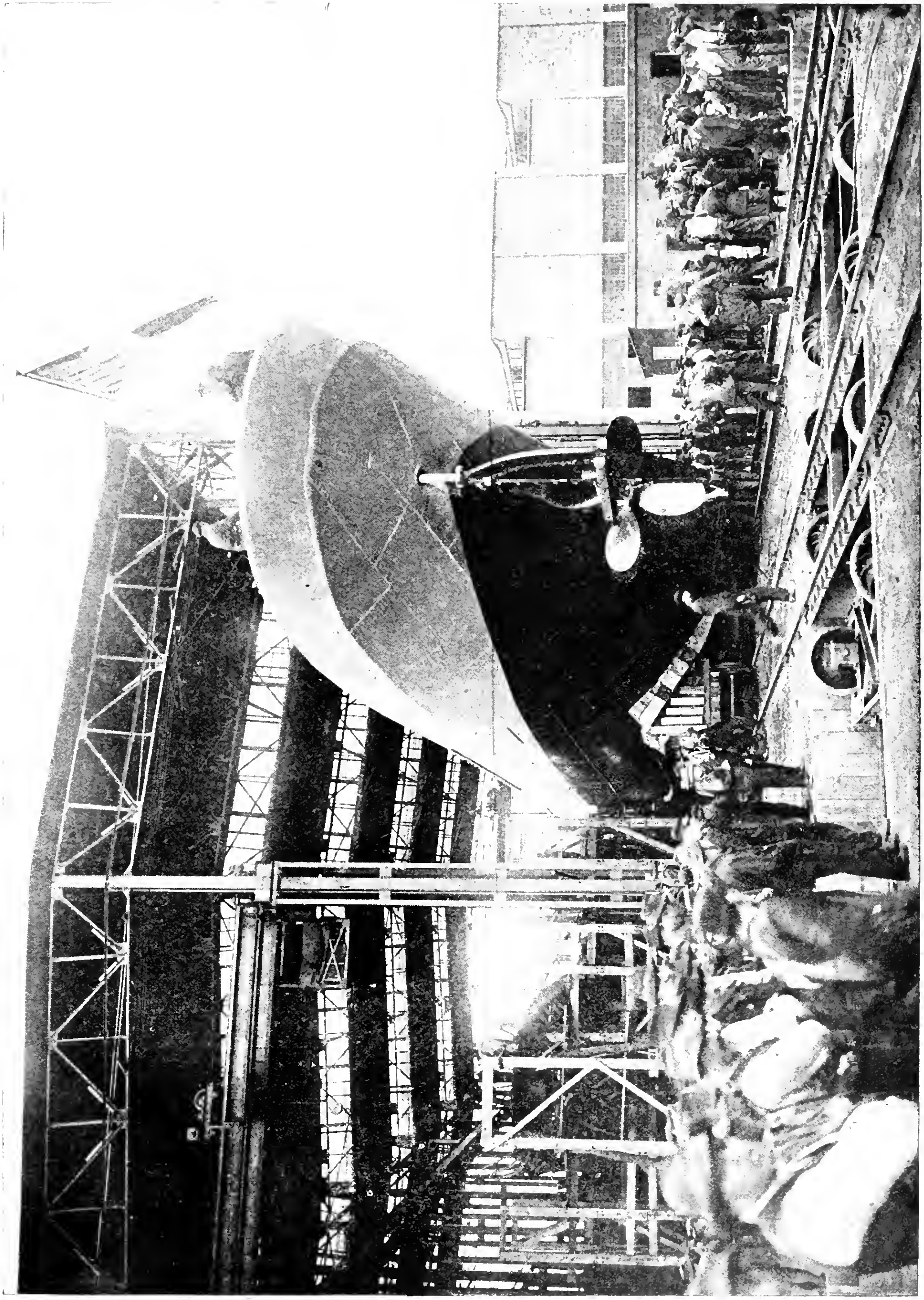


**PLATE II.**
Navarin just leaving building berth.

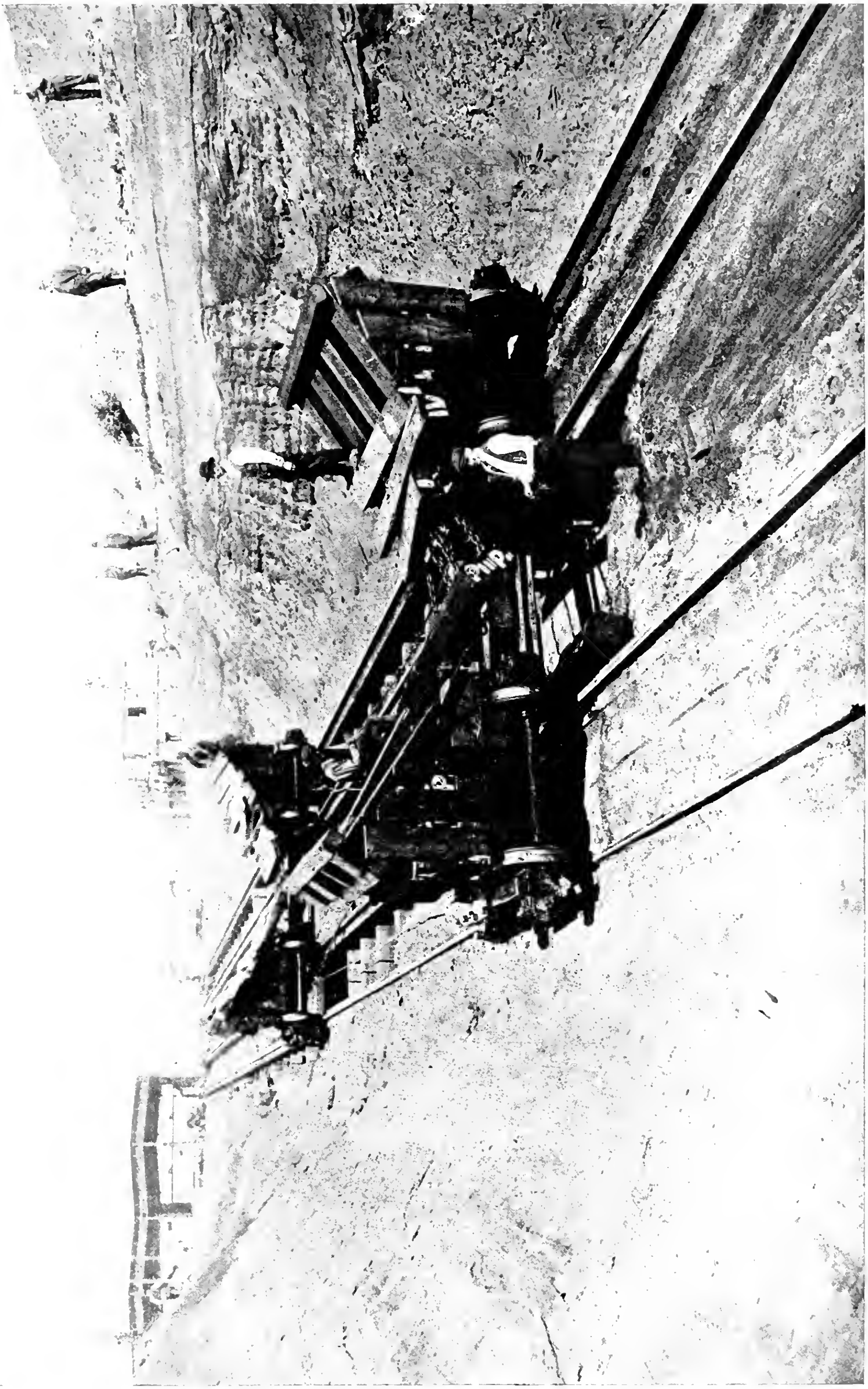


PLATE III.
Special trucks being pulled back after launching.

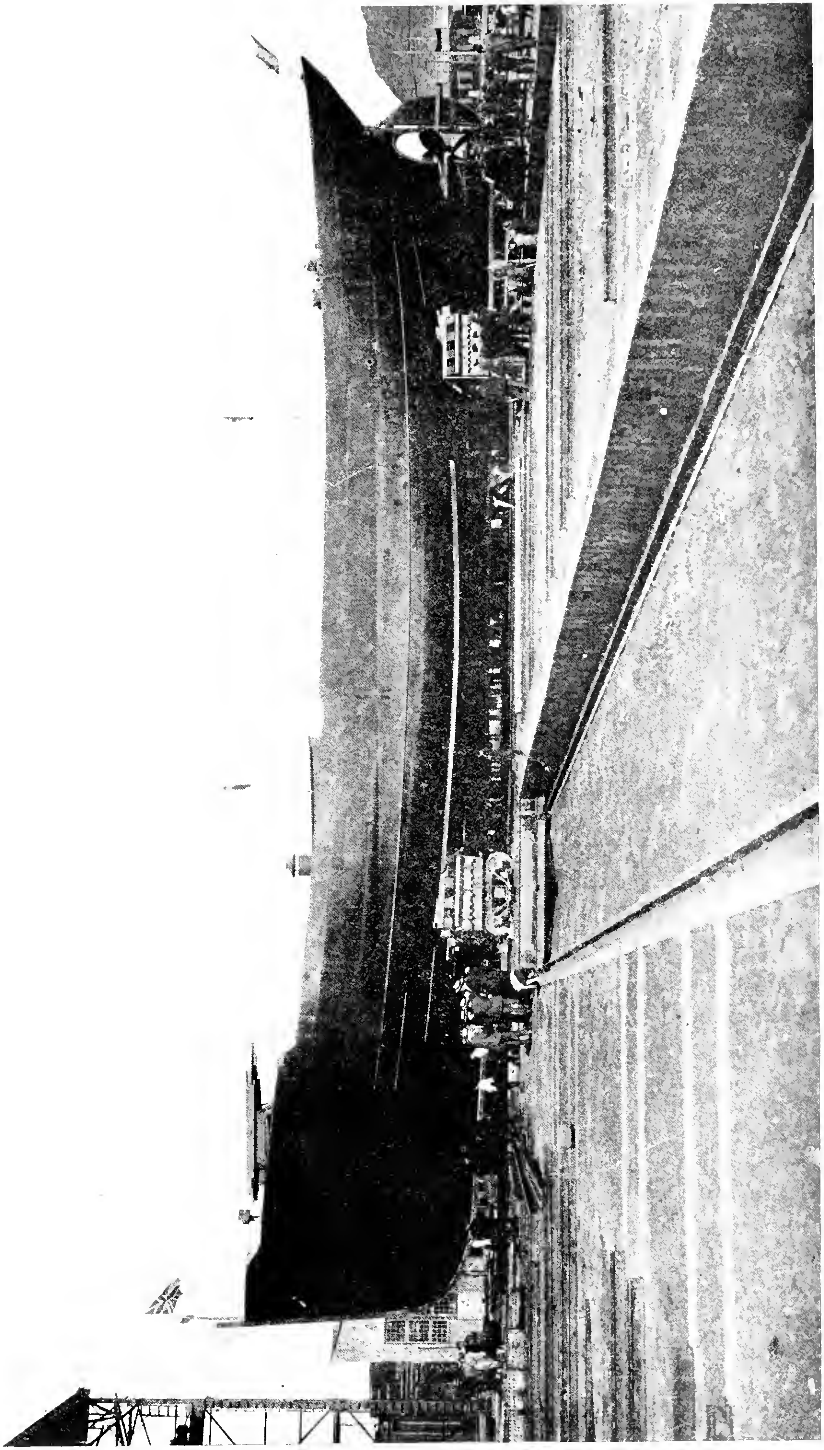


PLATE IV.
View of Montque on transfer table.

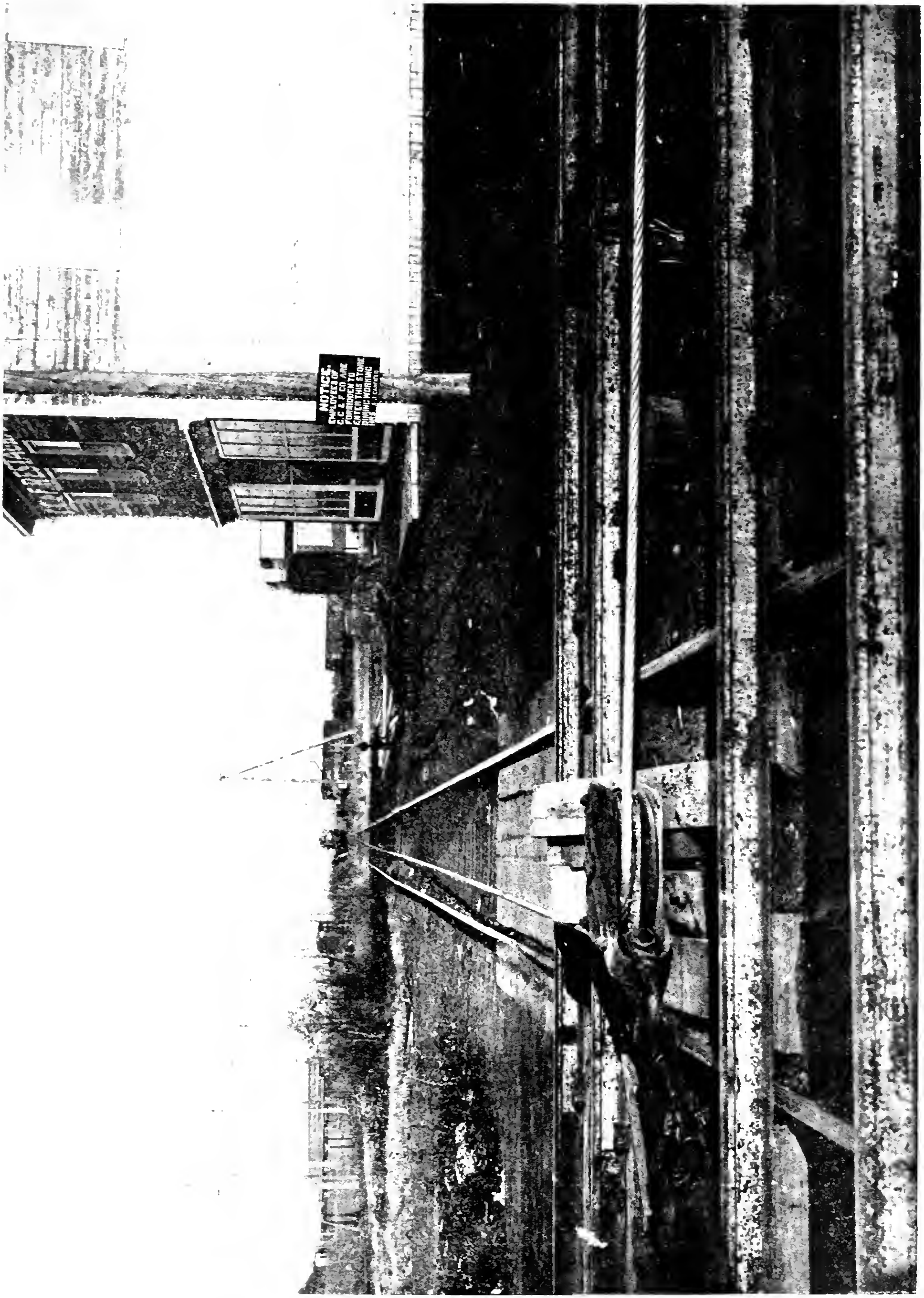



**PLATE V.**
View of engine and connecting cable for launching.

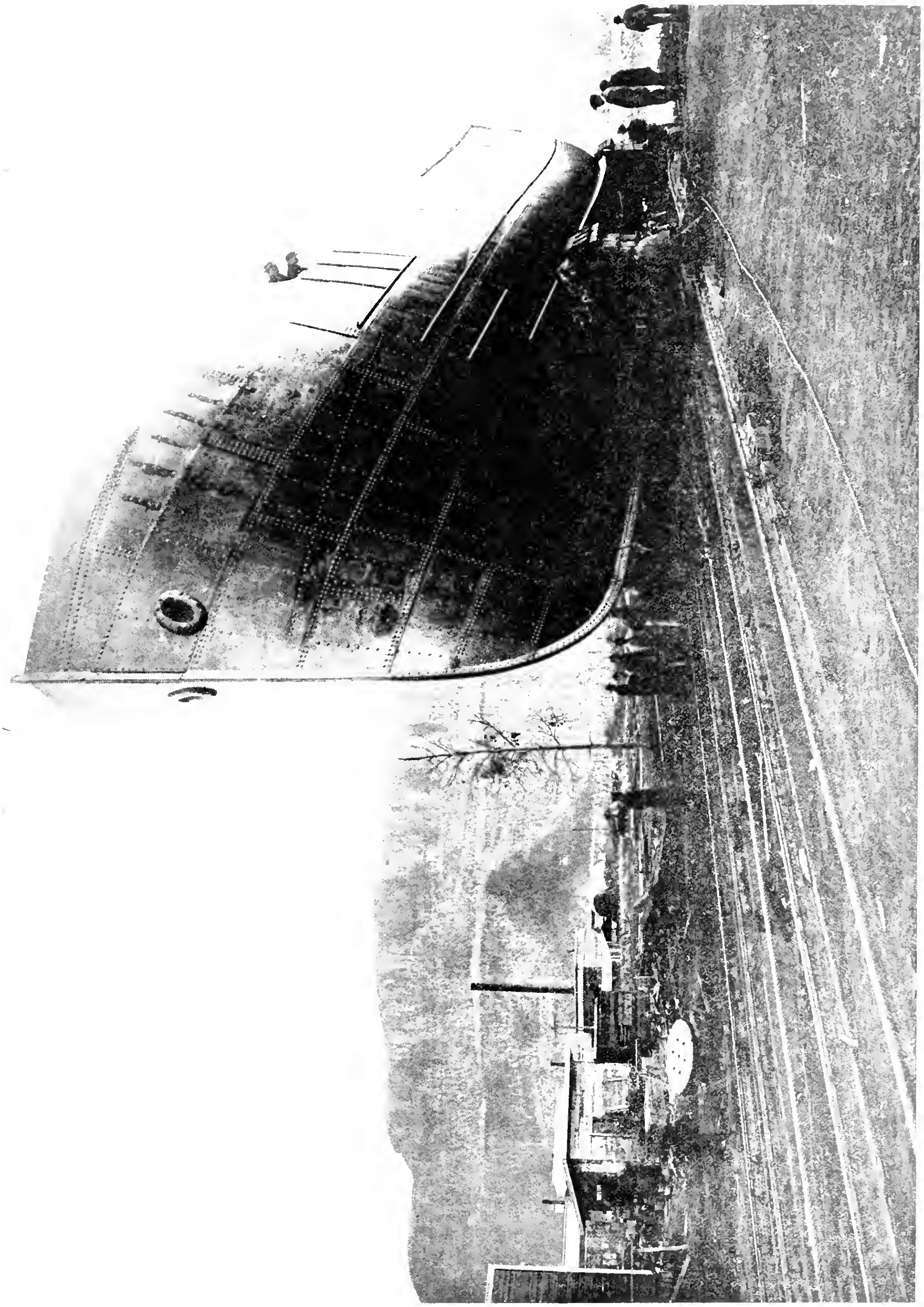


**PLATE VI.**
View showing cable connected to trucks for launching.

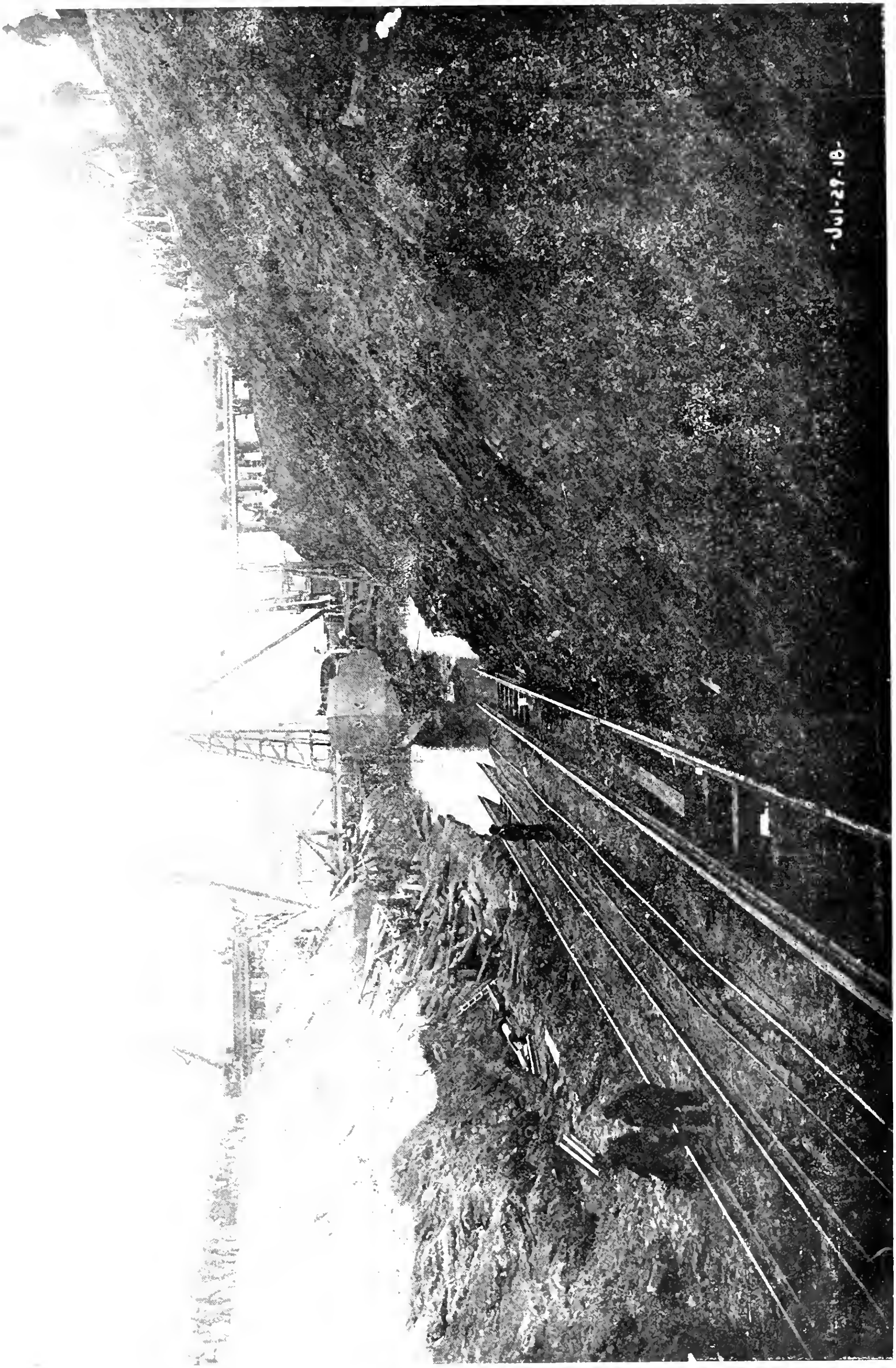



**PLATE VII.**
Navarin in water, inside temporary cofferdam.

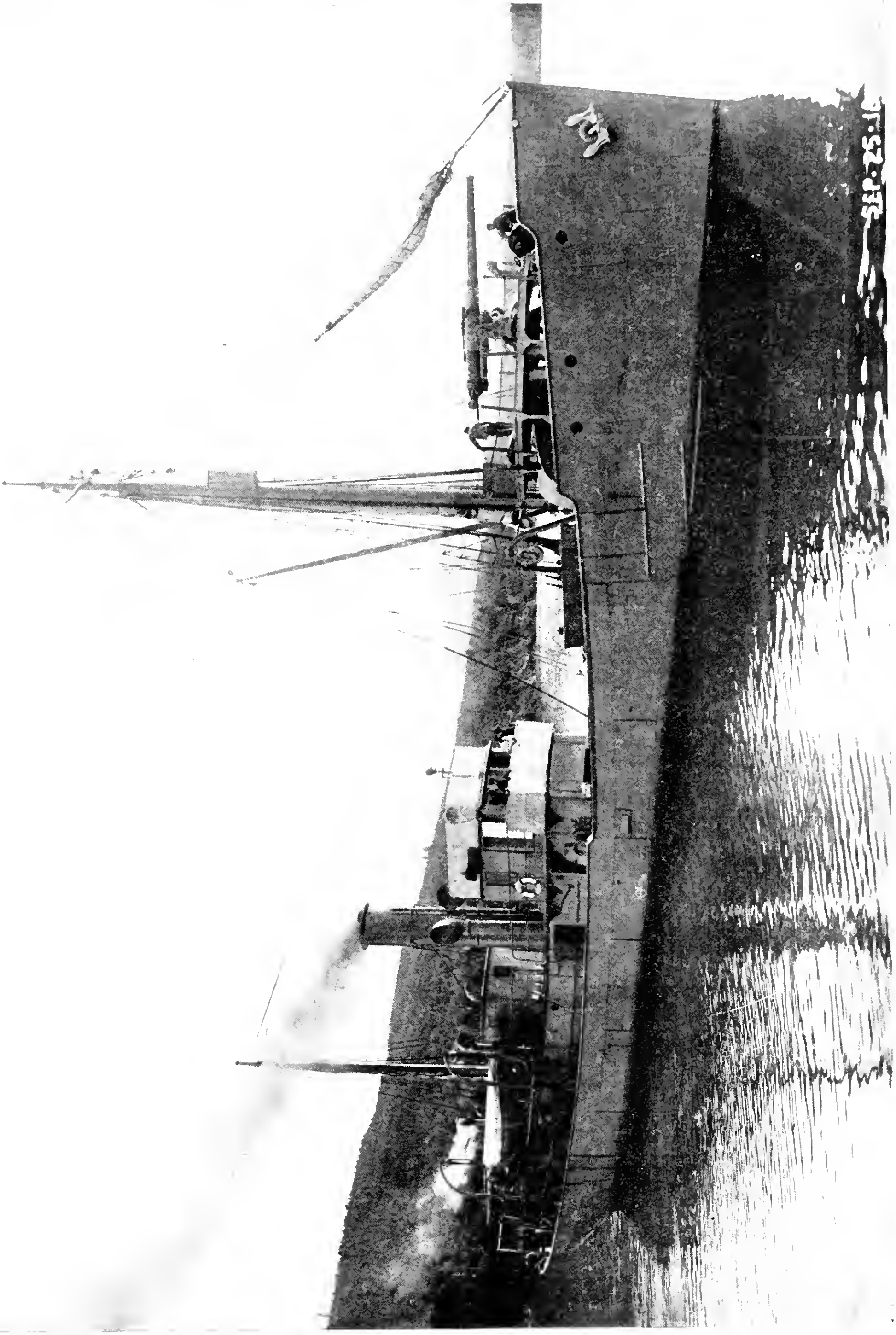


**PLATE VIII.**
View of Navarin completed ready for delivery.

## HAMILTON NOTES.

Mr. G. C. Willis, who has been with The Hamilton Bridge Works Co., Ltd., for nearly three years, expects to take up work in the Sales Dept. of The Standard Steel Construction Co., Ltd., of Welland, Ont., at the beginning of the year. This is the third man that the Bridge Works here will have lost to the Standard Steel Construction Co. within a period of not much over a year. Mr. Willis will remain in Hamilton and represent the Welland concern in this district and surrounding points.

---

A new concern that is expected to be in operation by the beginning of the year is "The Fox Chain Co. of Canada" an industry capitalized at $200,000. The new company is taking over the plant of the Ford Smith Machine Company on Princess and Earl Sts., who have recently put up a very fine new plant to accommodate the three smaller plants that they have had in different parts of the city.

The new concern will employ 40 to 50 hands at the commencement, but it is hoped that before long this number will be increased to about one hundred. Mr. Frank A. Fox is president of the new company and Mr. Wilfred North of New York is vice-president.

Mr. Fox has patents on some special types of anti-skid auto chains which is the product that will be manufactured.

Mr. Fox came to Hamilton three or four years ago, and started operations in a small way on York Street, but later sold out his interests except the patent rights and returned to New York where he has organized a strong company, and is now in a way to start operations on a larger scale with improved designs.

It appears that considerable effort was made by both Toronto and Welland to get the concern for those cities and credit is due to Mr. C. W. Kirkpatrick for his success in winning the new company for Hamilton.

---

A number of firms, including The Dominion Foundries & Steel Co. The Laidlaw Bale Tie Co., The Hamilton Bridge Works Co., have announced their intention of not engaging foreigners for work at the present time, and also letting out those at present employed, as quickly as their places can be filled by English-speaking men.

---

According to instructions all munition work stopped in this city on December 15th. Mr. G. Thompson, who has been in charge of the forging office in this city, received notice to close his office on that date and report to Ottawa. The office of the District Inspector will likely be the last to close, as much work has yet to be done. The majority of the employees of the munition board have now been discharged.

---

Mr. N. Cauchon, who assisted Mr. W. F. Tye in the preparation of the railway report for Hamilton, has been in the city recently again going into the matter. Mr. George A. Mountain, chief engineer of the Dominion Railway Board with a number of other officials made a trip of inspection over the proposed route with Mr. Grey, City Engineer, but nothing definite was done, it is hoped that at another meeting arranged for a later date, more actual results may be obtained.

---

From "Hamilton Spectator," Dec. 17th, 1918:

The Hamilton delegation from the Trades and Labor Council, which formed a part of the deputation which waited on Premier Hearst in Toronto yesterday, consisted of W. J. Lucas, business agent of the Ontario Moulders, ex-alderman Harry Halford, Gerald Murphy and Alderman Book.

One of the things which the local moulders urged upon the Premier was the appointment of an Inspector of Foundries.

Some of the foundries were described as death traps. It was urged that such an inspector should be an experienced moulder. The Premier promised consideration.

---

Mr. L. B. Johnston, who for a number of years has been Assistant Purchasing Agent at the Steel Company of Canada passed away at the end of last month from influenza. Mr. Johnston was one of the best liked men in the office, and will be very much missed, not only on account of the vacant position, but also for his continual cheerfulness and his readiness to always give a helping hand to any in need.

Mr. Johnston leaves a wife and two little children, to whom our deep sympathy goes out in their recent bereavement.

---

The Laidlaw Bale Tie Co. have recently put up a small addition to their office building.

---

The Dominion Foundries & Steel have completed their new Service Building, and are getting their patterns and other equipment moved into it. The Canadian Engineering and Contracting Co. have been contractors on the building and have made a fine job of the work.

---

The Hamilton Bridge Works have just completed a third furnace and bending floor for handling ship ribs for the American International Shipbuilding Co. of Hog Island, Pa.

The Bridge Works have been turning out a lot of ribs, plates and other parts for the ships being assembled at this immense new yard.

---

Looking back over the past year, one cannot but be struck with the immense lot of buildings that have gone up in the various large manufacturing plants. For almost every industry it has been a year of great prosperity, many of the plants have been working day and night at their fullest capacity, and though the strain under which so many have been working has now eased up, there does not seem to be any lack of work. The International Harvester Co. is advertising for laborers and other classes of help, and this and other firms seem to be absorbing any labor that is being laid off from other plants.

Perhaps the Steel Company of Canada would rank first for extensions to their plant during the year. This firm has about completed their new coke ovens. The first unit having been in operation for over a month is giving the utmost satisfaction. They have also put in a sheet mill this year which has been running very smoothly. A magnificent addition to their office building is also nearing completion, besides other smaller works that have been carried out.

The Dominion Foundries and Steel Co. have also done a lot of building this year. A large new forge building has been put into operation, a plate mill has been installed, a fine reinforced concrete and brick service building has been erected, important changes and additions have been made to the scrap yard crane runway, the machine shop, and to the power house. The oil

uks have been moved and new one installed. The truck layout has been largely altered, besides other smaller changes.

The Canadian Cartridge Co. have made large additions to their plant, making provision for a quick change from munition work to a more permanent line of things.

The Hamilton Bridge Co., Ltd., have put in two large additions to their east end plant for ship work.

The Burlington Steel Company have put up a good sized addition.

John Bertrams, of Dundas, have made large additions to their plant, putting in a fine new store room, etc.

The Acme Stamp and Tool Works have about completed a new building for their plant.

There has, of course, been much other building work among the smaller plants, some of which has been noted from time to time in these columns, and though perhaps the coming year will not call forth the same amount of work, certainly not the same type of work we will hope, still those in a position to know seem very optimistic about even the immediate future. The railways have been doing almost nothing towards the renewal or upkeep of bridges and it is rumored that orders of this class have already commenced to come in, and it is supposed to be more than rumor that the Dominion Foundries and Steel Co. are going ahead with a larger plate mill than the one already in operation. The Bridge Works have orders on ship work that will keep both their plants running full capacity for several months to come, and so in summing up the past and loking towards the future we would seem to be justified in saying that the prospects seem bright.

## BOOK REVIEW.

Powdered Coal as a Fuel, 6 x 9, 211 pages, by C. F. Herington, published by D. Van Nostrand Company, New York. Price $3.00. In his preface to this book the author indicates that he has drawn upon every available source for his information, and has endeavored to examine all systems without bias. He deals with his subject in ten chapters as follows:—

1. *Introductory*:
   General operation of plant—Comparison of Costs with Oil and Gas.
2. *Coals Suitable for Powdering*:
   Experience with various grades—Experiments—The ash question.
3. *Preparation of Powdered Coal*:
   Crushers—Dryers—Pulverizers—Air Separation.
4. *Feeding and Burning Powdered Coal*:
   Furnaces—Burners—Pneumatic Distribution.
5. *Powdered Coal in the Cement Industry*:
   Edison System—Kiln Calculations—Utilization of Waste Heat.
6. *Application of Powdered Coal to Reverberatory Furnaces*:
   Canadian Copper Company—Washoe Reduction Works—Anaconda Plant.
7. *Powdered Coal in Metallurgical Furnaces*:
   General Electric Company—Furnace Linings—American Locomotive Company—Lebanon Plant.
8. *Powdered Coal Under Boilers*:
   General Electric Company—American Locomotive Company.
9. *Powdered Coal for Locomotives*:
   Early Use—Operation—Tests.
10. *Explosions*:
    Storage Difficulties.

In the first a comparison of cost between powdered coal, oil, and gas is made and the figures, whilst showing the disadvantage of the first-named, indicate that rapid progress is being made in the utilization of fuel in this form. The second chapter deals with the various grades of coal suitable for powdering, and the ash question. This last appears to be one of the most troublesome factors and our own experience with open-hearth furnaces provided ample evidence of the choking effect on the checker work. The third and fourth chapters are devoted to the preparation and feeding of powdered coal, and also the pneumatic distribution of the same. Chapter five is given over to a consideration of this fuel as applied to cement making, and six to its use in reverberatory furnaces. The next two chapters (seven and eight) are utilized in dealing with its application to metallurgical furnaces, and under boilers, whilst nine and ten explain the early use, operation, and tests of powdered coal fuel for locomotives, and outline the storage difficulties and the problems of explosions. The book is liberally illustrated and gives in concise form the available data on the subject, and is of the utmost value at a time like the present, when all are interested in finding more economical and more efficient methods of generating and utilizing heat.

---

The Cleveland Milling Machine Company wish to announce that Mr W. P. Sparks is now connected with them as their representative at Indianapolis, Indiana, with offices at 316 Terminal Building.

---

The development of any industry depends upon the availability of raw materials. Nova Scotia has been able to develop an iron industry because of the unlimited supply of iron ore of satisfactory quality and of coal at points to which the ore can be cheaply carried.

---

Little or no coal finds its way from Nova Scotia to Ontario for smelting purposes. Ontario has been dependent on the United States. This scarcity of fuel which the Ontario iron industry had to face in early years has made possible the carrying of coal to plants which are located in a large and growing market area in Ontario. Coal and coke can be brought from Pennsylvania, Ohio and West Virginia to Canadian ports on the Great Lakes almost as cheaply as to American ports. For this reason the Algoma Steel Corporation purchased coal areas in West Virginia in 1911.

---

It is a common feature of economic development that changed technical conditions of an industry are reflected in the lagging or in the progress made by the industry of a particular country. England long held supremacy in the iron industry because of unsurpassed fuel supplies. The younger industry of the United States, handicapped by a later start and widely separated natural resources, won the ascendancy by a concentrated study of intensified production, the use of mechanical applications and labour-saving devices, and the assistance of cheap transportation.

# Electrochemistry and National Economy

By COLIN G. FINK.

(Presidential Address delivered at the Thirty-third General Meeting of the American Electrochemical Society at Knoxville, Tenn., April 30, 1918.)

The American Electrochemical Society considers itself very fortunate indeed to have the opportunity of undertaking this most interesting and highly instructive trip through the Appalachian South. What we have already seen more than convinces us that the Appalachian South is rapidly developing into one of the leading industrial centres of the world. We electrochemical engineers look upon Muscle Shoals as the new Niagara, the Niagara of the South.

What constitutes an electrochemical industrial centre? What are the essential requisites? What are the raw materials necessary for the production of that long list of metals, alloys, carbides, fertilizers, explosives, abrasives, lubricants, solvents, refractories, disinfectants, electrodes and gases for cutting and welding? The first essential is an abundant supply of cheap power—power to be had in large blocks for twenty-four hours a day and 365 days a year. Cheap power is almost always synonymous with water power—and of this the Appalachian South has been supplied by nature in gracious abundance. In the State of Tennessee alone, according to the estimates of Professor J. A. Switzer of the University of Tennessee, there are available almost one million horse power. In other words, Tennessee alone has enough power available to foster an electrochemical industry twice the size of that existing at Niagara Falls today. When our government decided to establish nitrogen fixation factories in this country and considered the various localities suitable for the electrochemical production of those most vital compounds, ammonia and nitrates—without which we could neither feed our populace nor defend our borders—our government, after due deliberation, most wisely decided to erect the "air saltpeter" factories at Muscle Shoals, Alabama. Therefore, as regards the supply of cheap water power in the Appalachian South, there is no doubt. Careful surveys have reported a vast abundance. In this connection it is gratifying indeed to note that the United States Chamber of Commerce, composed of 500,000 business executives from every State and Territory in the country, a few weeks ago unanimously adopted resolutions calling on Congress to make provision for harnessing the millions in water horse-power that are now going to waste.

The development of our water power resources is of prime national economic value. It means the saving of coal and oil, which though most abundant here in the South are nevertheless exhaustible, and once used can never be replaced; it means the saving of railroad equipment now used for the transportation of coal and oil; it means the saving of a long list of valuable chemical products now burned and wasted under thousands of boilers; and it means the saving of millions of dollars in labor. The water power generated in the Province of Ontario, Canada, has reduced coal consumption between five and six million tons per annum. Under fairly efficient working conditions it requires from two to six pounds of coal to generate power equivalent to one horse-power-hour. Think of the tons and tons of coal represented by the available water horse power of this country, which is estimated by the Geological Survey at 32 millions, minimum potential.

The electrochemist looks upon the vast coal resources of the Appalachian South as intended for purposes of greater economic value. The coal reserves of a single State, West Virginia, have been calculated at 150 billion tons. The Southern coal makes the best coke, and when making coke very valuable by-products are conserved, which are lost when coal is burned under boilers. Alabama is the second largest coke producing State in the country. Tons of coke are shipped from the South to Niagara Falls and there heated in contact with sand in large electric furnaces that produce temperatures that are higher than can be attained in any other way. A beautiful crystalline product is obtained, carborundum, a silicon carbide, an abrasive which has found worldwide application. Another important electrochemical product largely dependent upon Appalachian coke is calcium carbide. This was first made by Willson at Spray, North Carolina, in 1891, by mixing ordinary limestone and coke and heating to very high temperatures in the electric furnace. Calcium carbide is the source of acetylene which is used in conjunction with electrolytically produced oxygen in the oxy-acetylene torch for steel welding and steel cutting. You are all familiar with this time- and labor-saving device. Calcium carbide furthermore serves as the "raw material" in the manufacture of cyanamid, which the government will soon be turning out by the ton at Muscle Shoals. From cyanamid we obtain ammonia and this can be oxidized to nitric acid. Cyanamid is likewise a very efficient fertilizer. Another and very recent by-product of calcium carbide is acetone, which is consumed in large quantities in the manufacture of explosives. There seems to be no end to the list of electrochemical and chemical compounds and products of inestimable worth that are all primarily derived from Appalachian coke.

The South has been most strikingly favored by nature in the line of raw materials for electrochemical products. Next in importance to her coke resources are her extensive deposits of bauxite, the basic mineral from which that "metal of many uses," aluminum, is derived. The aluminum industry of this country ranks among the very first and consumes almost as much in kilowatts as all the other electrochemical industries put together. There are but four States in the whole country that have been mining bauxite in commercial quantities—Arkansas, Georgia, Alabama and Tennessee. In 1917 these States turned out 400,000 metric tons of bauxite, which is 12 per cent more than the world's bauxite output of the year 1910. The Aluminum Company of America has erected a large metal-producing plant at Maryville, Tennessee. This appears to us as a very wise move. Why ship bauxite by freight hundreds of miles away? Why not make the metal near the source of the raw material? Why ship two tons of bauxite in place of one ton of aluminum metal?

Bauxite is also used for the manufacture of aloxite, alundum and exolon, artificial emeries of great hardness and uniformity, which are made in electric furnaces. The artificial abrasives, alundum, aloxite, carborundum and carbolon, have practically replaced imported emery and corundum. They have furthermore virtually revolutionized the machine shops, doubling and trebling their output.

The electrochemical industry which is most typically American is the electrolytic copper refining industry. Over 75 per cent of the copper consumed today is purified and refined by electro-chemical methods. It is of the highest attainable quality, exceeding in purity most commercial metals. The largest electrolytic copper plant in the world is located at Canto, Maryland, with an annual production of 720 million pounds. The modern electrical industry with its dynamos and motors, its telephone, telegraph and wireless, and its countless electromagnetic devices would be hopelessly crippled if we were to deprive it of electrolytic copper.

In the electric steel industry the United States likewise leads the world. The quality of electric steel surpasses that of the best crucible steel. Next to Minnesota and Michigan, Alabama is the largest iron ore producing State in the Union. Over 50 per cent of the iron ore reserves of the United States are located here in the South. Large electric steel furnaces are in operation at Chattanooga, Tennessee, and Anniston, Alabama.

Closely linked with the electric steel industry is the electric ferro-alloy industry — ferro-manganese, ferro-silicon, ferro-chromium, ferro-titanium and others. Ferro-silicon and other ferro-alloys, are electrically made by the Southern Ferro-Alloys Co. at Chattanooga, Tennessee. Electric ferro-manganese is made by the Southern Manganese Corporation, Anniston, Alabama. Deposits of manganese occur in many parts of the United States, but are most abundant in the Appalachian and Piedmont regions, Virginia and Georgia being the largest producers, and Tennessee the best "quality" producer. Silicon is derived from quartz rock or sand. Titanium is derived from the mineral "rutile." For many years the sole producer of rutile in this country has been the American Rutile Company, whose plant is at Roseland, Virginia. Rails made of steel to which ferro-titanium is added during the process of manufacture, are less liable to breakage, and are 40 per cent more durable than are ordinary open-hearth rails. Another electric titanium alloy is cupro-titanium, containing 10 per cent titanium and 90 per cent copper. This is extensively used in making sound castings of copper and bronze.

Carbon bisulphide is a solvent upon which the rubber industry is very much dependent. Formerly it was made by tedious and expensive processes. Today all carbon bisulphide is made electro-chemically. The raw materials are charcoal and sulphur. The great sulphur States of the world are Louisiana and Texas. The combined output of these two States exceeds not only that of all other States put together, but that of all the rest of the world. One of the many wells of the Union Sulphur Company discharges 500 tons of sulphur per day.

If we arrange the electrochemical industries according to the number of factories and the total power consumed, both in this country and abroad, we find that the electrolytic alkali and chlorine industry ranks fourth in the list. What a long array of interesting and important products have been developed and turned out